

MAXYMILLIAN TECHNOLOGIES, INC.
(formerly CLEAN BERKSHIRES, INC.)
(Thermal Desorption System)

TECHNOLOGY DESCRIPTION:

The Maxymillian Technologies, Inc., Mobile Thermal Desorption System (TDS) uses rotary kiln technology to remove contaminants from soils. The TDS can remediate soils contaminated with volatile organic compounds (VOC), semivolatile organic compounds (SVOC), and polynuclear aromatic hydrocarbons (PAH). The TDS is fully transportable, requires a footprint of 100-by-140 feet, and can be set up on site in 4 to 6 weeks. The system combines high throughput with the ability to remediate mixed consistency soil, including sands, silts, clays, and tars.

The TDS consists of the following components (see figure below):

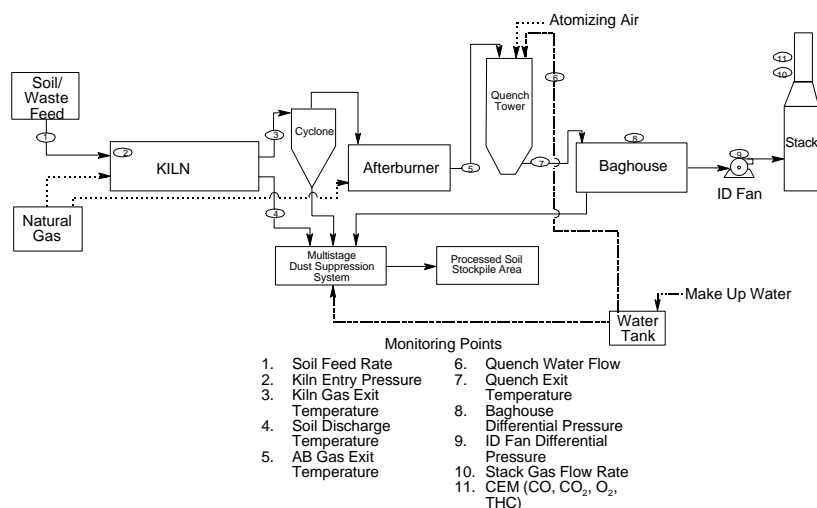
- Waste feed system
- Rotary kiln drum desorber
- Cyclone
- Afterburner
- Quench tower
- Baghouse
- Fan and exhaust stack

- Multistage dust suppression system
- Process control room

Soil is first shredded, crushed, and screened to achieve a uniform particle size of less than 0.75 inch. Feed soils are also mixed to achieve uniform moisture content and heating value.

The thermal treatment process involves two steps: contaminant volatilization followed by gas treatment. During the volatilization step, contaminated materials are exposed to temperatures ranging from 600 to 1,000 °F in a co-current flow rotary kiln drum desorber; contaminants volatilize to the gas phase. Clean soils are then discharged through a multistage dust suppression system for remoisturization and are stockpiled for testing.

The gas and particulate stream passes from the kiln to the cyclone, where coarse particles are removed. The stream then enters the afterburner, which destroys airborne contaminants at temperatures ranging from 1,600 to 2,000 °F. The gas stream is cooled by quenching before passing through a high-efficiency baghouse, where fine particles are



Mobile Thermal Desorption System

removed. The clean gas is then released to the atmosphere through a 60-foot stack. Processed soil, after discharge from the dust suppression system, is stockpiled and allowed to cool prior to sampling.

WASTE APPLICABILITY:

The TDS is designed to remove a wide variety of contaminants from soil, including VOCs, SVOCs, PAHs, coal tars, and cyanide.

STATUS:

The TDS was accepted into the SITE Demonstration Program in 1993. The demonstration was conducted in November and December 1993 at the Niagara Mohawk Power Corporation Harbor Point site, a former gas plant in Utica, New York. During the demonstration, the TDS processed three replicate runs of four separate waste streams. Stack emissions and processed soil were measured to determine achievement of cleanup levels. The Demonstration Bulletin (EPA/540/MR-94/507) and Technology Capsule (EPA/540/R-94/507a) are available from EPA.

Following the SITE demonstration, the TDS was chosen to remediate approximately 17,000 tons of VOC-contaminated soil at the Fulton Terminals Superfund site in Fulton, New York. This project was completed in 1995. The system has since been moved to a location in North Adams, Massachusetts.

DEMONSTRATION RESULTS:

Results from the SITE Demonstration are summarized below:

- The TDS achieved destruction removal efficiencies (DRE) of 99.99 percent or better in all 12 runs using total xylenes as a volatile principal organic hazardous constituent (POHC).

- DREs of 99.99 percent or better were achieved in 11 of 12 runs using naphthalene as a semivolatile POHC.
- Average concentrations for critical pollutants in treated soils were 0.066 milligram per kilogram (mg/kg) benzene, toluene, ethylbenzene, and xylene (BTEX); 12.4 mg/kg PAHs; and 5.4 mg/kg total cyanide.
- Comparison of the dry weight basis concentration of pollutants in the feed and treated soil showed the following average removal efficiencies: 99.9 percent for BTEX; 98.6 percent for PAHs; and 97.4 percent for total cyanide.
- The TDS showed good operating stability during the demonstration with only a minor amount of downtime.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Ronald Lewis

U.S. EPA

National Risk Management Research

Laboratory

26 West Martin Luther King Drive

Cincinnati, OH 45268

513-569-7856

Fax: 513-569-7105

TECHNOLOGY DEVELOPER CONTACT:

Neal Maxymillian

Maxymillian Technologies, Inc.

84 State Street

Boston, MA 02109

617-557-6077

Fax: 617-557-6088

**MORRISON KNUDSEN CORPORATION/
SPETSTAMPONAZHGEOLGIA ENTERPRISES**
(Clay-Based Grouting Technology)

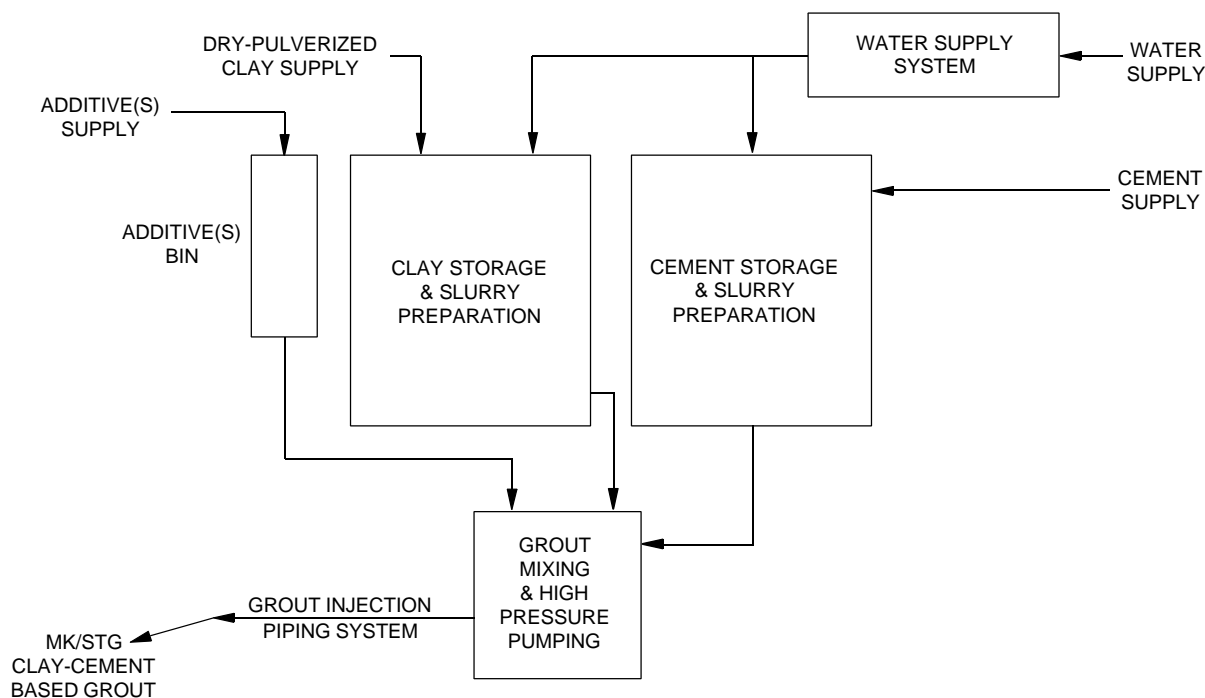
TECHNOLOGY DESCRIPTION:

Morrison Knudsen Corporation (MK) is working under a joint venture agreement with Spetstamponazhgeologia Enterprises (STG) of Ukraine to demonstrate the effectiveness of a clay-based grouting technology. This technology uses clay slurries as a base for grout solutions, which are injected into bedrock fracture systems to inhibit or eliminate groundwater flow in these pathways. The clay slurries may also be used as a base for slurry wall construction.

The MK/STG clay-based grouting technology is an integrated method involving three primary phases: obtaining detailed site characteristics; developing a site-specific grout formulation; and grout mixing and injection. The first phase, site characterization, includes obtaining geophysical, geochemical, mineralogical, and hydrogeological information about the target area.

The second phase, a site-specific grout formulation, is developed in the laboratory. The overall properties of clay-based grout depend on the physical and mechanical properties of the clay, cement, and other additives. Formulated clay-based grouts are viscoplastic systems composed primarily of clay mineral mortar and structure-forming cement. The clay is normally a kaolin/illite obtained from a local source; other additives may be required. The formulation is laboratory-tested to determine suitability for the desired application.

The third phase is grout mixing and placement. The process for preparing and injecting the clay-based grout is shown in the diagram below. Boreholes drilled during the site characterization phase may be used for grout placement. Additional boreholes may be drilled to complete the injection program. A quality assurance program ensures that placement and project objectives are met. After injection, the clay-based grout retains its plasticity and does not



Process Flow Diagram of the Clay-Based Grouting Technology

crystallize, providing permanent underground protection.

WASTE APPLICABILITY:

This technology is suitable for providing a flow barrier to groundwater contaminated with both heavy metals and organics. The clay-based grout can be formulated to withstand detrimental conditions such as low pH. The technology can be used at inactive mine sites that produce acid mine drainage. Other potential applications include liquid effluent control from landfills, containment of groundwater contaminated with chemicals or radionuclides, and reduction of brine inflows.

STATUS:

This technology was accepted into the SITE Demonstration Program in winter 1993. It was partially installed in fall 1994 at the abandoned Mike Horse Mine site in Montana; operations were suspended due to winter weather conditions. The second phase, to complete installation of the grout, was canceled due to EPA budget constraints. The demonstration was completed in 1996, but the technology was not fully evaluated due to loss of accessibility to the site.

Over 200 projects using this technology have been completed during the last 20 years in the former Soviet Union and Eastern block countries, as well as in China and Australia. The technology has not been applied in the United States or western hemisphere other than at the Mike Horse Mine site.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Jack Hubbard
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7507
Fax: 513-569-7620

TECHNOLOGY DEVELOPER CONTACTS:

Kathryn Levihn
Rick Raymondi
Morrison Knudsen Corporation/STG
P.O. Box 73
Boise, ID 83729
208-386-6115
Fax: 208-386-6669

NATIONAL RISK MANAGEMENT RESEARCH LABORATORY (Base-Catalyzed Decomposition Process)

TECHNOLOGY DESCRIPTION:

The base-catalyzed decomposition (BCD) process is a chemical dehalogenation technology developed by the National Risk Management Research Laboratory in Cincinnati, Ohio. The process is initiated in a medium-temperature thermal desorber (MTTD) at temperatures ranging from 600 to 950 °F. Sodium bicarbonate is added to contaminated soils, sediments, or sludge matrices containing hazardous chlorinated organics including polychlorinated biphenyls (PCB) and polychlorinated dioxins and furans. Chlorinated contaminants that are thermally desorbed from the matrix are condensed and treated by the BCD process. The BCD process chemically detoxifies the condensed chlorinated organic contaminants by removing chlorine from the contaminants and replacing it with hydrogen.

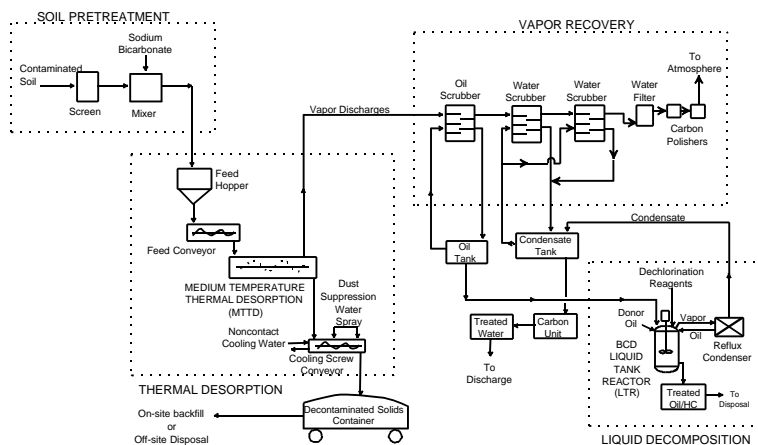
ETG Environmental, Inc. (ETG), and Separation and Recovery Systems, Inc. (SRS), developed the THERM-O-DETOX® and SAREX® systems and combined them with the BCD process chemistry. The combined process begins by initiating solid-phase dechlorination in the MTTD step (see figure below). In addition to the dechlorination that occurs in the MTTD, organics are thermally desorbed from the matrix, and are condensed and sent to the BCD liquid tank reactor (LTR).

Reagents are then added and heated to 600 to 650 °F for 3 to 6 hours to dechlorinate the remaining organics. The treated residuals are recycled or disposed of using standard, commercially available methods. Treated, clean soil can be recycled as on-site backfill.

ETG has continued to develop the THERM-O-DETOX® system and now offers continuous systems and batch vacuum systems. The batch vacuum system offers greater operational flexibility for removal and destruction of high hazard, high boiling point contaminants to ensure that treatment standards are met. The vapor recovery system can be set up to use noncontact condensers or chillers and additional final polishing steps to meet the most stringent air emission standards.

WASTE APPLICABILITY:

The BCD process can treat soils, sediments, and sludges contaminated with the following chlorinated compounds: halogenated semivolatile organic compounds (SVOC), including herbicides and pesticides; PCBs; pentachlorophenol (PCP) and other chlorinated phenols; and polychlorinated dioxins and furans.



Base-Catalyzed Dechlorination (BCD) Process

STATUS:

The combined BCD process was demonstrated under the SITE Program at the Koppers Company Superfund site in Morrisville, North Carolina from August through September 1993. The process removed PCP from clay soils to levels below those specified in the record of decision. The process also removed dioxins and furans from contaminated soil to 2,3,7,8-tetrachlorodibenzo-p-dioxins equivalent concentrations less than the concentration specified in the Record of Decision.

ETG is also currently operating the batch vacuum system at a New York State Department of Environmental Conservation cleanup site in Binghamton, New York. Approximately 1500 cubic yards of soil contaminated with herbicides pesticides, dioxins, and furans (F027 waste) are being treated. The Michigan Department of Natural Resources has also approved BCD for a project involving treatment of about 200 cubic yards of F027 soils. At another site, multiple systems will treat soils contaminated with chlorinated volatile organic compounds and high boiling point (800-1150 °F) organic lubricants. The batch vacuum system has also been used to treat sludges at an operating refinery in Puerto Rico and a chemical company in Texas.

For information on the SAREX® system, see the profile for SRS in the Demonstration Program section (ongoing projects).

DEMONSTRATION RESULTS:

The SITE demonstration consisted of four test runs in the MTTD and two test runs in the LTR. Feed soil consisted of a dry, clayey silt and had a residence time of 1 to 2 hours in the MTTD, which was heated to 790 °F to 850 °F. The MTTD off-gases were treated by passing through an oil scrubber, water scrubbers, and carbon filters. The oil from the oil scrubber was transferred to the LTR for BCD treatment. The oil in each LTR test run was batch-processed for 3 to 4 hours at 600 to 630°F.

Key findings from the SITE demonstration are summarized as follows:

- The MTTD achieved removal efficiencies of 99.97 percent or better for PCP and 99.56 percent or better for total dioxins and total furans.
- The treated soils were well below toxicity characteristic leaching procedure limits for SVOCs.
- Treated soil met the cleanup goals of 95 parts per million PCP in all test runs. Treated soil also met a cleanup goal of 7 micrograms per kilogram 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalents in all test runs.
- The LTR batch tests reduced PCP concentrations by 96.89 percent or better, and total dioxin and total furan concentrations by 99.97 percent or better.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Terrence Lyons
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7589
Fax: 513-569-7676

TECHNOLOGY DEVELOPER CONTACTS:

George Huffman
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive, MS-445
Cincinnati, OH 45268
513-569-7431
Fax: 513-569-7549

Yei-Shong Shieh or Steven Detwiler
ETG Environmental, Inc.
16 Hagerty Boulevard
West Chester, PA 19382-7594
610-431-9100
Fax: 610-431-9140

NATIONAL RISK MANAGEMENT RESEARCH LABORATORY (Volume Reduction Unit)

TECHNOLOGY DESCRIPTION:

The volume reduction unit (VRU) is a pilot-scale, mobile soil washing system designed to remove organic contaminants and metals from soil through particle size separation and solubilization. The VRU can process 100 pounds of soil (dry weight) per hour.

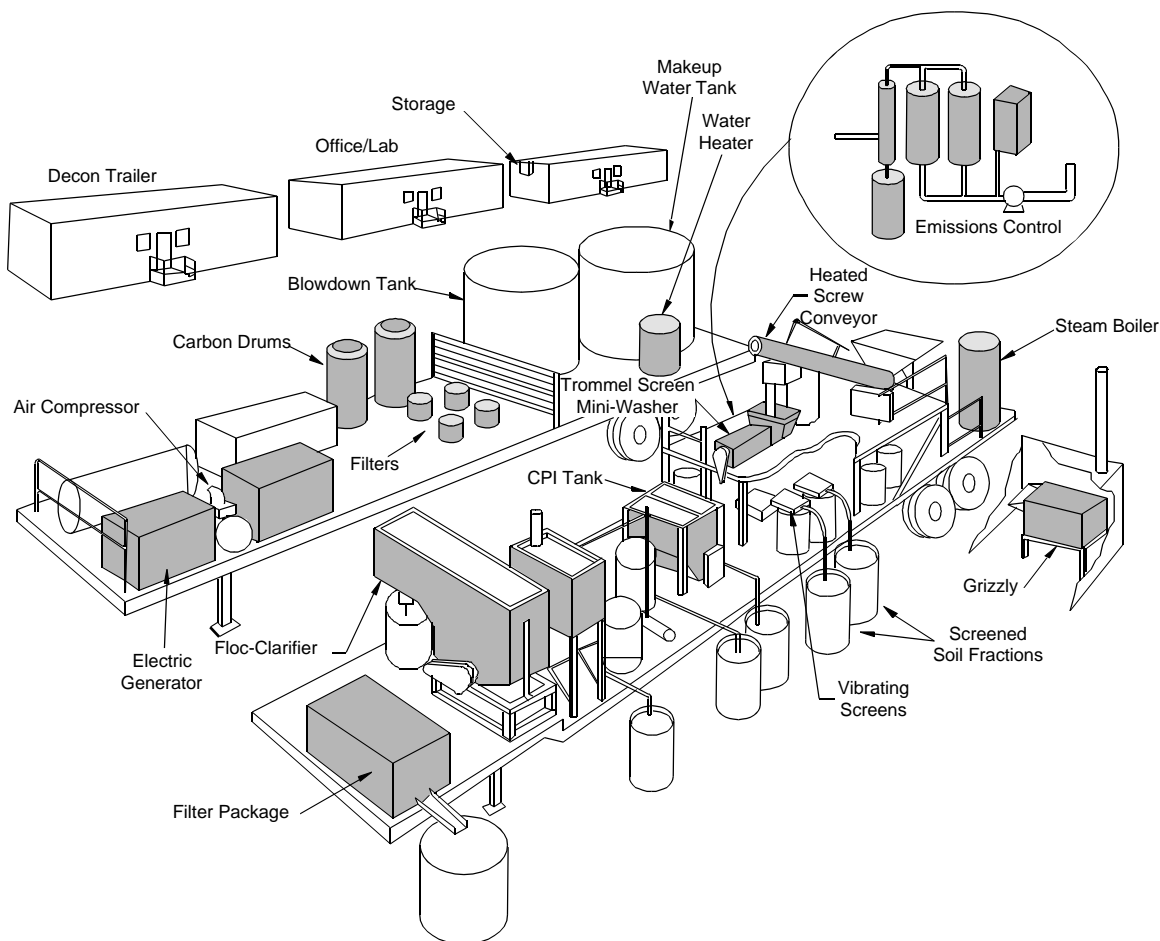
The process subsystems consist of soil handling and conveying, soil washing and coarse screening, fine particle separation, flocculation-clarification, water treatment, and utilities. The VRU is controlled and

monitored with conventional industrial process instrumentation and hardware.

WASTE APPLICABILITY:

The VRU can treat soils that contain organics such as creosote, pentachlorophenol (PCP), pesticides, polynuclear aromatic hydrocarbons (PAH), volatile organic compounds, and semivolatile organic compounds. The VRU also removes metals.

STATUS:



Typical VRU Operational Setup

The VRU was accepted into the SITE Demonstration Program in summer 1992. The demonstration was conducted in November 1992 at the former Escambia Treating Company in Pensacola, Florida. The facility used PCP and creosote PAHs to treat wood products from 1943 to 1982. The Applications Analysis Report (EPA/540/AR-93/508) is available from EPA.

DEMONSTRATION RESULTS:

During the demonstration, the VRU operated at a feed rate of approximately 100 pounds per hour and a wash water-to-feed ratio of about six to one. The following physical wash water conditions were created by varying the surfactant, pH, and temperature:

- Condition 1 - no surfactant, no pH adjustment, no temperature adjustment
- Condition 2 - surfactant addition, no pH adjustment, no temperature adjustment
- Condition 3 - surfactant addition, pH adjustment, and temperature adjustment

The table below summarizes the analytical data.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Teri Richardson
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7949
Fax: 513-569-7105

TECHNOLOGY DEVELOPER CONTACT:

Richard Griffiths
U.S. EPA
National Risk Management Research
Laboratory
Center Hill Facility
5595 Center Hill Road
Cincinnati, OH 45224
513-569-7832
Fax: 513-569-7879

	Condition (%)		
	1	2	3
Average PCP removal	80	93	97
Average PAH removal	79	84	96
Feed soil returned as washed soil	96	96	81
Mass balance of total mass	104	113	98
Mass balance of PCPs	108	60	24
Mass balance of PAHs	87	60	17

Demonstration Data

**NATIONAL RISK MANAGEMENT
RESEARCH LABORATORY
and INTECH 180 CORPORATION
(Fungal Treatment Technology)**

TECHNOLOGY DESCRIPTION:

This biological treatment system uses lignin-degrading fungi to treat excavated soils. These fungi have been shown to biodegrade a wide catalogue of organic contaminants.

The contaminated soil is inoculated with an organic carrier infested with the selected fungal strain. The fungi break down soil contaminants, using enzymes normally produced for wood degradation as well as other enzyme systems.

This technology has the greatest degree of success when optimal growing conditions for the fungi are used. These conditions include moisture control (at 90 percent of field capacity), and temperature and aeration control. Organic nutrients such as peat may be added to soils deficient in organic carbon.

WASTE APPLICABILITY:

This biological treatment system was initially applied to soil contaminated with organic chemicals found in the wood-preserving industry. These contaminants are composed of chlorinated organics and polynuclear aromatic hydrocarbons (PAH). The treatment system may remediate different contaminants and combinations of contaminants with varying degrees of success. In particular, the SITE Demonstration Program evaluated how well white rot fungi degrade pentachlorophenol (PCP) in

combination with creosote PAHs.

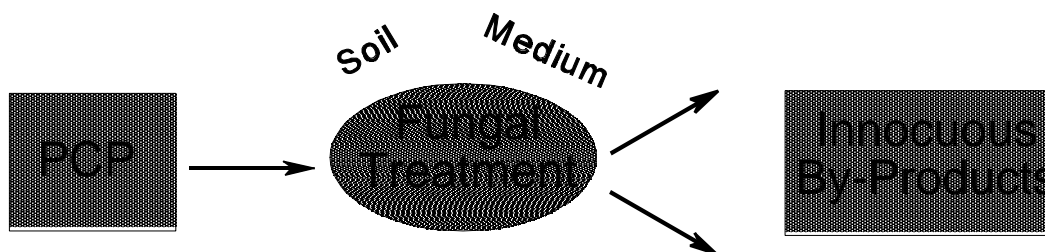
STATUS:

This biological treatment system was accepted into the SITE Demonstration Program in April 1991. In September 1991, a treatability study was conducted at the Brookhaven Wood Preserving site in Brookhaven, Mississippi. Site soils were contaminated with 200 to 5,200 milligrams per kilogram (mg/kg) PCP and up to 4,000 mg/kg PAHs.

A full-scale demonstration of this fungal treatment technology was completed in November 1992 to obtain economic data. The Demonstration Bulletin (EPA/540/MR-93/505) is available from EPA.

The extent of treatment in the full-scale demonstration was disappointing for the time of treatment. The full-scale demonstration was hampered by excessive rainfall which did not permit the treatment beds to be sufficiently tilled. Without this processing, oxygen-depleted conditions developed, leading to loss of fungal biomass and activity. Soil bed applications of this technology may not be suitable in climates of high rainfall.

Current costs of fungal treatment operation are estimated at \$150 to \$200 per ton. Lower costs may be achieved with new inoculum formulations which permit reduction in the amount of inoculum



In Situ White Rot Fungal Treatment of Contaminated Soil

mass required for treatment.

DEMONSTRATION RESULTS:

The full-scale project involved a 0.25-acre plot of contaminated soil and two smaller control plots. The soil was inoculated with *Phanaerochaete sordida*, a species of lignin-degrading fungus. No other amendments were added to the prepared soil. Field activities included tilling and watering all plots. No nutrients were added. The study was conducted for 20 weeks.

Some key findings from the demonstration were:

- Levels of PCP and the target PAHs found in the underlying sand layer and the leachate from each of the plots were insignificant, indicating low leachability and loss of these contaminants due to periodic irrigation of the soil and heavy rainfall.
- Levels of PCP, the target PAHs, and dioxins in the active air samples collected during the soil tilling events were insignificant, indicating a very low potential for airborne contaminant transport.

- Air emissions data showed that soil tilling activities did not pose significant hazards to field technicians. Contaminated soil, underlying sand, and leachate had no significant contamination.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Teri Richardson
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7949
Fax: 513-569-7105

TECHNOLOGY DEVELOPER CONTACTS:

John Glaser
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7568
Fax: 513-569-7105

Richard Lamar
INTECH 180 Corporation
1770 N. Research Parkway, Suite 100
North Logan, UT 84341
801-753-2111
Fax: 801-753-8321

NATIONAL RISK MANAGEMENT RESEARCH LABORATORY and IT CORPORATION (Debris Washing System)

TECHNOLOGY DESCRIPTION:

This technology was developed by EPA's National Risk Management Research Laboratory and IT Corporation (IT) for on-site decontamination of metallic and masonry debris at Comprehensive Environmental Response, Compensation, and Liability Act sites. The entire system is mounted on three 48-foot flatbed semi-trailers and can be readily transported from site to site.

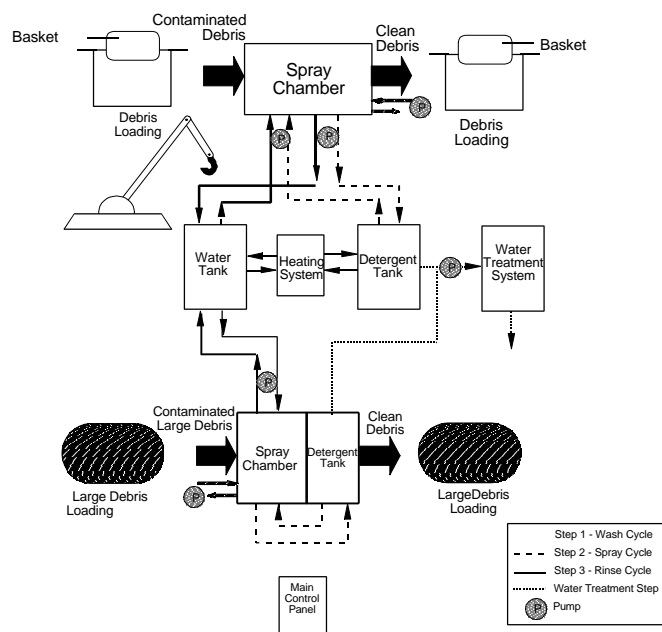
The full-scale debris washing system (DWS) is shown in the figure below. The DWS consists of dual 4,000-gallon spray-wash chambers that are connected to a detergent solution holding tank and rinse water holding tank. Debris is placed into one of two 1,200-pound baskets, which in turn is placed into one of the spray-wash chambers using a 5-ton crane integral to the DWS. If debris is large enough, the crane places it directly into one of the two chambers. Process water is heated to 160 °F using

a diesel-fired, 2,000,000-British-thermal-unit-per-hour (Btu/hr) water heater. The water is continuously reconditioned using particulate filters, an oil-water separator, and other devices such as charcoal columns or ion-exchange columns. About 8,000 to 10,000 gallons of water is required for the decontamination process. The system is controlled by an operator stationed in a trailer-mounted control room.

WASTE APPLICABILITY:

The DWS can be applied on site to various types of debris (scrap metal, masonry, or other solid debris such as stones) contaminated with hazardous chemicals such as pesticides, dioxins, polychlorinated biphenyls (PCB), or hazardous metals.

STATUS:



Pilot-Scale Debris Washing System

The first pilot-scale tests were performed in September 1988 at the Carter Industrial Superfund site in Detroit, Michigan. An upgraded pilot-scale DWS was tested at a PCB-contaminated Superfund site in Hopkinsville, Kentucky in December 1989. The DWS was also field tested in August 1990 at the Shaver's Farm Superfund site in Walker County, Georgia. The contaminants of concern were benzonitrile and Dicamba. After being cut into sections, 55-gallon drums were decontaminated in the DWS.

Results from the SITE demonstration have been published in a Technology Evaluation Report (EPA/540/5-91/006a), entitled "Design and Development of a Pilot-Scale Debris Decontamination System" and in a Technology Demonstration Summary (EPA/540/S5-91/006).

In 1993, a manual version of the full-scale DWS was used to treat PCB-contaminated scrap metal at the Summit Scrap Yard in Akron, Ohio. During the 4-month site remediation, 3,000 tons of PCB-contaminated scrap metal (motors, cast iron blocks) was cleaned on site. The target level of 7.7 $\mu\text{g}/100\text{ cm}^2$ was met, in most cases, after a single treatment with the DWS. The cleaned scrap was purchased by a scrap smelter for \$52 per ton. The net costs for the on-site debris decontamination ranged from \$50 to \$75 per ton. The National Risk Management Research Laboratory and IT estimate that the system can decontaminate 50 to 120 tons of typical debris per day.

DEMONSTRATION RESULTS:

At the Carter Industrial Superfund site, PCB reductions averaged 58 percent in batch 1 and 81 percent in batch 2. Design changes based on these tests were made to the DWS before additional field testing.

At the Hopkinsville, Kentucky site, PCB levels on the surfaces of metallic transformer casings were reduced to less than or equal to 10 micrograms PCB per 100 square centimeters ($\mu\text{g}/\text{cm}^2$). All 75 contaminated transformer casings on site were decontaminated to EPA cleanup criteria and sold to a scrap metal dealer.

At the Shaver's Farm Superfund site, benzonitrile and Dicamba levels on the drum surfaces were reduced from the average pretreatment concentrations of 4,556 and 23 $\mu\text{g}/100\text{ cm}^2$ to average concentrations of 10 and 1 $\mu\text{g}/100\text{ cm}^2$, respectively.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Donald Sanning
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7875
Fax: 513-569-7620

TECHNOLOGY DEVELOPER CONTACTS:

Michael Taylor or Majid Dosani
IT Corporation
11499 Chester Road
Cincinnati, OH 45246-4012
513-782-4700
Fax: 513-782-4807

**NATIONAL RISK MANAGEMENT
RESEARCH LABORATORY,
UNIVERSITY OF CINCINNATI, and FRX, INC.
(Hydraulic Fracturing)**

TECHNOLOGY DESCRIPTION:

Hydraulic fracturing is a physical process that creates fractures in soils to enhance fluid or vapor flow in the subsurface. The technology places fractures at discrete depths with hydraulic pressurization at the base of a borehole. These fractures are placed at specific locations and depths to increase the effectiveness of treatment technologies such as soil vapor extraction, in situ bioremediation, and pump-and-treat systems. The technology is designed to enhance remediation in less permeable geologic formations.

The fracturing process begins by injecting water into a sealed borehole until the water pressure exceeds a critical value and a fracture is nucleated (see photograph below). A slurry composed of a coarse-grained sand, or other granular material, and guar gum gel is then injected as the fracture grows away from the well. After pumping, the grains hold the fracture open while an enzyme additive breaks down

the viscous fluid. The thinned fluid is pumped from the fracture, forming a permeable subsurface channel suitable for delivering or recovering a vapor or liquid. These fractures function as pathways for fluid movement, potentially increasing the effective area available for remediation.

The hydraulic fracturing process is used in conjunction with soil vapor extraction technology to enhance recovery of contaminated soil vapors. Hydraulic fractures have recently been used to improve recovery of light nonaqueous phase liquids by increasing recovery of free product and controlling the influence of underlying water. Hydraulically induced fractures are used as channels for fluids and nutrients during in situ bioremediation. The technology has the potential to deliver nutrients and other materials to the subsurface solids useful in bioremediation. Solid nutrients or oxygen-releasing granules can be injected into the fractures.

Real-time techniques for measuring ground surface



Hydraulic Fracturing Process (Well is at Center of Photograph)

deformation have been developed to monitor the fracture positions in the subsurface.

WASTE APPLICABILITY:

Hydraulic fracturing is appropriate for enhancing soil and groundwater remediation. The technology can channel contaminants or wastes for soil vapor extraction, bioremediation, or pump-and-treat systems.

STATUS:

The hydraulic fracturing technology was accepted into the SITE Demonstration Program in July 1991. Demonstrations have been conducted in Oak Brook, Illinois and Dayton, Ohio. The hydraulic fracturing process was integrated with soil vapor extraction at the Illinois site and with in situ bioremediation at the Ohio site. The project was completed in September 1992. The Technology Evaluation and Applications Analysis Reports, which were published under one cover (EPA/540/R-93/505), and the Technology Demonstration Summary (EPA/540/SR-93/505) are available from EPA.

DEMONSTRATION RESULTS:

The first demonstration was conducted at a Xerox Corporation site in Oak Brook, Illinois, where a vapor extraction system has been operating since early 1991. The site is contaminated with ethylbenzene, 1,1-dichloroethane, trichloro-ethene, tetrachloroethene, 1,1,1-trichloroethane, toluene, and xylene. In July 1991, hydraulic fractures were created in two of the four wells, at depths of 6, 10, and 15 feet below ground surface. The vapor flow rate, soil vacuum, and contaminant yields from the fractured and unfractured wells were monitored regularly. Results from this demonstration are as follows:

- Over a 1-year period, the vapor yield from hydraulically fractured wells was one order of magnitude greater than from unfractured wells.
- The hydraulically fractured wells enhanced remediation over an area 30 times greater than the unfractured wells.

- The presence of pore water decreased the vapor yield from wells; therefore, water must be prevented from infiltrating areas where vapor extraction is underway.

The technology was also demonstrated at a site near Dayton, Ohio, which is contaminated with benzene, toluene, ethylbenzene, and xylene (BTEX), and other petroleum hydrocarbons. In August 1991, hydraulic fractures were created in one of two wells at 4, 6, 8, and 10 feet below ground surface. Sampling was conducted before the demonstration and twice during the demonstration at locations 5, 10, and 15 feet north of the fractured and unfractured wells. Results from this demonstration are as follows:

- The flow of water into the fractured well was two orders of magnitude greater than in the unfractured well.
- The bioremediation rate near the fractured well was 75 percent higher for BTEX and 77 percent higher for total petroleum hydrocarbons compared to the rates near the unfractured well.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Michael Roulier
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7796
Fax: 513-569-7620

TECHNOLOGY DEVELOPER CONTACT:

William Slack
FRX Inc.
P.O. Box 37945
Cincinnati, OH 45222
513-469-6040
Fax: 513-469-9747

**NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL
CONSERVATION/ENSR CONSULTING AND ENGINEERING
and LARSEN ENGINEERS
(Ex Situ Biovault)**

TECHNOLOGY DESCRIPTION:

The Ex Situ Biovault, developed by ENSR Consulting and Engineering (ENSR) and Larsen Engineers (Larsen), is a specially designed, aboveground soil pile designed to treat soils contaminated with volatile organic compounds (VOC) and semivolatile organic compounds (SVOC). The biovault is enclosed by a double liner system; the bottom half of the liner contains a leak detection system. The bottom half of the liner is supported by soil berms which serve as side walls.

To construct a biopile, a layer of gravel containing an air distribution system is placed on the bottom liner. The soil to be treated is then placed over the gravel. After placing the soil, a layer of sand containing a second air distribution system is placed on top of the soil. Soaker hoses are also placed on top of the pile. Finally, the top liner is placed on the pile and sealed at all seams. The air distribution systems are designed to control gas flows throughout the pile while the soaker hoses add water and nutrients. A sump is located in the lowest corner of the biovault with a pump that removes the liquids that drain through the soil pile. This liquid is amended with nutrients as needed and recirculated through the soaker hoses. Together, the sump and

soaker hoses form the liquid management system (LMS).

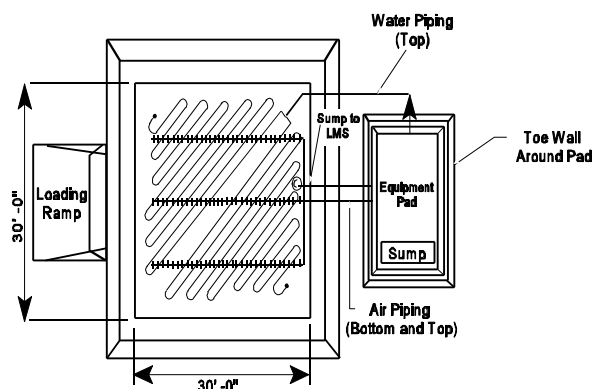
One of the control parameters for biovault operation is the rate of air supply. For the SITE demonstration, two identical vaults were constructed. One vault was operated with a continuous supply of air throughout the course of treatment. In the other vault, air was supplied intermittently; as a result, this biovault operated under aerobic and anaerobic conditions.

WASTE APPLICABILITY:

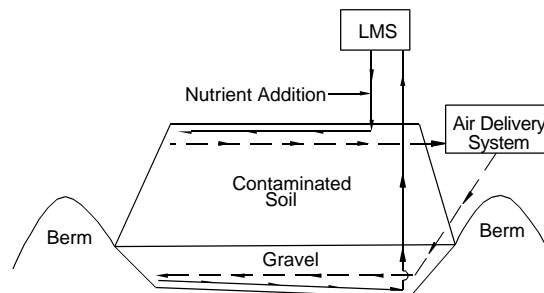
The ex situ biovault is intended to treat soil contaminated with chlorinated and nonchlorinated VOCs, as well as SVOCs. Soil contaminated with VOCs was treated during the demonstration.

STATUS:

ENSR's and Larsen's ex situ biovault was accepted into the SITE Demonstration Program in June 1994. The pilot-scale, multivendor treatability demonstration (MVTVD) was jointly sponsored by the New York State Department of Environmental Conservation (NYSDEC), the New York State Center for Hazardous Waste Management, and the



Schematic of the Ex Situ Biovault System



Cross Section of the
Ex Situ Biovault System

SITE Program. The objectives of the MVTD were to (1) generate field data for biological processes, and (2) evaluate the performance of each biological process in meeting NYSDEC cleanup goals.

The demonstration was conducted from July to December 1994 at the Sweden 3-Chapman site in Sweden, New York and coincided with ongoing remediation at the site. The soil at the site was contaminated with elevated levels of acetone, trichloroethene, tetrachloroethene, cis-1,2-dichloroethene, 2-butanone, 4-methyl-2-pentanone, and toluene.

In addition to the ENSR and Larsen process, the following systems were also demonstrated:

- SBP Technologies, Inc., Vacuum-Vaporized Well System
- R.E. Wright Environmental, Inc., In Situ Bioventing Treatment System

For information on these technologies, refer to the NYSDEC profiles in the Demonstration Program section (completed projects).

The Demonstration Bulletin (EPA/540/MR-95/524) is available from EPA. The Innovative Technology Evaluation Report, which provides more detailed demonstration results, will be available in 1997.

DEMONSTRATION RESULTS:

The primary objective of the SITE demonstration was to determine the effectiveness of the biovaults in reducing the concentrations of six target VOCs. The results of the ex situ biovault technology demonstration were as follows:

- Soil concentrations of six target VOCs were significantly reduced over the 5-month demonstration period, but the treatment did not meet NYSDEC criteria.
- Analytical results and field measurements indicated that both biovaults supported biological processes.
- The aerobic and aerobic/anaerobic biovaults performed similarly.

The biovault process is sensitive to ambient temperatures, and cool temperatures during the operating period may have negatively impacted microbial activity. The developers suggest initiating biovault operation in the spring and discontinuing operation when weather conditions become too cold to sustain microbial activity.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Carolyn Acheson

U.S. EPA

National Risk Management Research

Laboratory

26 West Martin Luther King Drive

Cincinnati, OH 45268

513-569-7190

Fax: 513-569-7105

TECHNOLOGY DEVELOPER CONTACTS:

Nick Kolak

New York State Department of

Environmental Conservation

50 Wolf Road, Room 268

Albany, NY 12233-7010

518-457-3372

Fax: 518-457-7743

David Ramsden

ENSR Consulting and Engineering

3000 Richmond Avenue

Houston, TX 77098

713-520-9900

Fax: 713-520-6802

N. Sathiyakumar

Larsen Engineers

700 West Metro Park

Rochester, NY 14623-2678

716-272-7310

Fax: 716-272-0159

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION/SBP TECHNOLOGIES, INC. (Vacuum-Vaporized Well System)

TECHNOLOGY DESCRIPTION:

The SBP Technologies, Inc. (SBP), remediation program uses an in situ Unterdruck-Verdampfer-Brunnen (UVB) vertical groundwater circulation well technology, which has been enhanced with an in situ bioreactor to treat contaminated soil and groundwater. This process consists of a specially adapted groundwater circulation well, reduced pressure stripping reactor, an in situ bioreactor, and an aboveground vapor-phase bioreactor.

The UVB technology was developed by IEG mbH in Germany and is distributed in the U.S. by IEG Technologies Corporation. SBP obtained the exclusive rights to implement this technology and enhanced it to create a more effective in situ bioremediation technology.

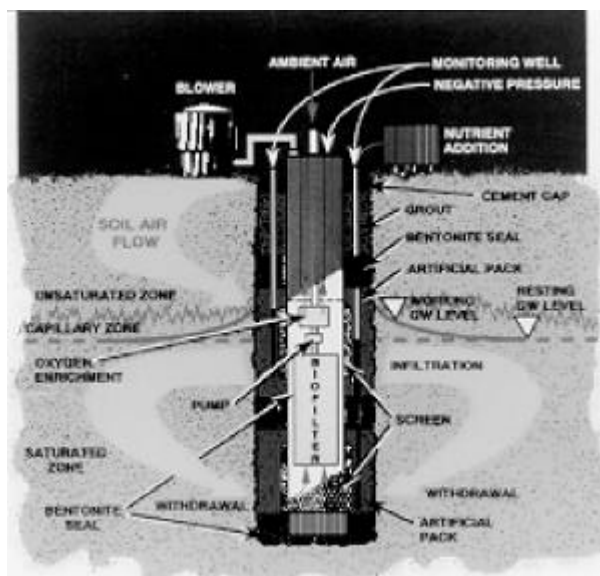
The microbiologically enhanced vertical circulation well technology simultaneously treats the vadose zone, capillary fringe, and saturated zones. During the demonstration, a groundwater convection (circulation) cell was created radially within the aquifer around the 16-inch UVB well. The UVB well consisted of upper and lower screens separated

by a solid riser casing (see the figure below). The lower screen was isolated from the upper screen by a packer, creating two separate screened zones. Contaminated groundwater flowed into the lower screen of the UVB well and was pumped to the upper section. The water rose through the in situ fixed film bioreactor, initially reducing the contaminant load. Groundwater then flowed to the in situ aerator/stripping reactor, where fresh ambient air was mixed with the contaminated groundwater.

The convection cell was developed by allowing the treated groundwater to exit into the upper aquifer. The untreated volatile organic compounds (VOC) exiting the in situ bioreactor system were stripped before the groundwater flowed out of the upper screen into the aquifer as clean water. Oxygenated groundwater from the shallow aquifer circulated to the deep aquifer zone and through the fixed film bioreactor to provide for aerobic degradation. This circulation created an 80-foot-diameter remediation circulation cell in a glacial till geologic formation.

In conjunction with the groundwater remediation, the upper double-cased screen in the well allowed for a one-way soil air flow from the vadose zone to the UVB. This one-way soil venting, created by the reduced pressure developed in the well by the blower, remediated the contaminated unsaturated and capillary fringe zones simultaneously.

The off-gases from the in situ aerator/stripping reactor passed through an ex situ gas phase bioreactor for further biotreatment followed by granular activated carbon treatment before being vented. This bioreactor consisted of spirally wound, microporous, polyvinyl chloride-silica sheets that served as a biosupport for *Pseudomonas cepacia* (strain 17616), a known trichloroethene (TCE) degrader. VOCs in the off-gases, such as toluene, benzene, xylene, TCE, and others were also biologically treated through a cometabolic process in the gas phase bioreactor.



Vacuum-Vaporized Well (UVB)
System Standard Circulation

WASTE APPLICABILITY:

This technology treats soil and groundwater contaminated with chlorinated and nonchlorinated VOCs.

STATUS:

The UVB system was accepted into the SITE Demonstration Program in June 1994. The pilot-scale, multivendor treatability demonstration (MVTD) was jointly sponsored by the New York State Department of Environmental Conservation (NYSDEC), the New York State Center for Hazardous Waste Management, and the SITE Program. The objectives of the MVTD were to (1) generate field data for three biological processes, and (2) evaluate the performance of each biological process in meeting NYSDEC cleanup goals.

The demonstration took place at the Sweden 3-Chapman site in Sweden, New York. Field work began in July 1994 and was completed in fall 1995. Final reports from the demonstration will be available in 1997.

The UVB demonstration coincided with the remediation of the site. Soil at the site contained elevated levels of TCE, acetone, tetrachloroethene, dichloroethene, and toluene. The contaminants of concern (COC) were monitored at 15 groundwater monitoring wells, across the in situ bioreactor, the vadose zone soils, and the ex situ bioreactor to evaluate the system's performance. A dye tracer test was conducted to determine the extent of the groundwater circulation cell.

In addition to the SBP process, the following technologies were also demonstrated:

- R.E. Wright Environmental, Inc., In Situ Bioventing Treatment System
- ENSR Consulting and Engineering and Larsen Engineers Ex Situ Biovault

For information on these technologies, refer to the NYSDEC profiles in the Demonstration Program section (completed projects).

DEMONSTRATION RESULTS:

During the demonstration, an in situ vertical groundwater circulation cell was established with an effective radius of 40 feet. The UVB system reduced the concentration of COCs in groundwater. The in situ bioreactor provided biotreatment of the COCs in the dissolved phase. Also, removal of COCs from soils was demonstrated. An ex situ bioreactor was effective in treating off-gas vapors from the UVB system prior to final polishing. Mass balance calculations determined that at least 75 percent of the target COCs in soil and groundwater, within the UVB's radius of influence, were removed during the demonstration.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Michelle Simon
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7469
Fax: 513-569-7676

TECHNOLOGY DEVELOPER CONTACTS:

Nick Kolak
New York State Department of
Environmental Conservation
50 Wolf Road, Room 268
Albany, NY 12233-7010
518-457-3372
Fax: 518-457-7743

Richard Desrosiers
SBP Technologies, Inc.
106 Corporate Park Drive
White Plains, NY 10604
914-694-2280
Fax: 914-694-2286

**NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL
CONSERVATION/R.E. WRIGHT ENVIRONMENTAL, INC.
(In Situ Bioventing Treatment System)**

TECHNOLOGY DESCRIPTION:

The R.E. Wright Environmental, Inc. (REWEL), process uses bioventing technology to induce aerobic biological degradation of chlorinated compounds. A series of extraction and injection wells is used to amend the soil environment, creating optimum growth conditions for the indigenous bacteria. Anhydrous ammonia and methane are injected into the subsurface to stimulate the growth of methanotrophic microorganisms. Methanotrophs have the enzymatic capabilities to degrade chlorinated solvents through a cometabolic process.

The treatment system consists of an injection and extraction well field and a soil gas extraction-amendment injection blower unit (see photograph below). The blower unit is operated in the vacuum mode long enough to adequately aerate the subsoil and provide oxygen for the

aerobic bacteria. Injection wells are located between the extraction wells and are manifolded to the pressure port of the blower unit. Anhydrous ammonia is periodically injected into the subsoil to provide a source of nitrogen for the aerobic bacteria. In addition, methane gas is periodically injected to stimulate the growth of methanotrophs. The positive displacement blower unit is equipped with a moisture knockout tank, an automatic water discharge pump, and a control panel that allows remote operation of the system. Air and water discharges are typically treated with granular activated carbon prior to final discharge.

Normal system monitoring consists of periodic soil sampling and analysis and soil gas monitoring. Soil samples are collected and analyzed for volatile organic compounds (VOC), soil fertility parameters, and microbiological parameters such as trichloroethene (TCE)



In Situ Bioventing Treatment System

degraders and methanotrophs. In situ respiration tests are conducted to determine the relative activity of the bacteria in the soil.

WASTE APPLICABILITY:

The technology can treat both chlorinated and nonchlorinated VOCs and semivolatile organic compounds that are biodegradable. The REWEI process was developed to treat volatile chlorinated aliphatic and aromatic hydrocarbons in the unsaturated soil zone.

STATUS:

The REWEI process was accepted into the SITE Demonstration Program in June 1994. The REWEI process was part of a pilot-scale, multivendor treatability demonstration (MVTD) that was jointly sponsored by the New York State Department of Environmental Conservation (NYSDEC), the New York State Center for Hazardous Waste Management, and the SITE Program. The objectives of the MVTD were to (1) generate field data for three biological processes, and (2) evaluate the performance of each biological process in meeting NYSDEC cleanup goals.

The demonstration took place from July to December 1994 at the Sweden 3-Chapman site in Sweden, New York and coincided with the ongoing remediation of the site. Soil at the site contained elevated levels of TCE, acetone, tetrachloroethene, dichloroethene, and toluene. The Demonstration Bulletin (EPA/540/MR-95/525) is available from EPA. The Innovative Technology Evaluation Report, which provides more detailed demonstration results, will be available in 1997.

In addition to the REWEI process, the following technologies were also demonstrated:

- SBP Technologies, Inc., Vacuum-Vaporized Well system
- ENSR Consulting and Engineering and Larsen Engineers Ex Situ Biovault

For information on these technologies, refer to the NYSDEC profiles in the Demonstration Program section (completed projects).

DEMONSTRATION RESULTS:

The SITE demonstration results indicated that the REWEI process reduced contaminants in the soil. The initial mass of TCE in the soil was reduced by 92 percent with 80 percent removal attributed to biodegradation and 12 percent removed by vapor extraction. Results of the microbiological analyses indicate that the number of total heterotrophic, TCE-degrading, and methane-degrading microorganisms increased during treatment. The inorganic soil nitrogen content increased due to the subsurface injection of anhydrous ammonia.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Greg Sayles
National Risk Management Research
Laboratory
U.S. EPA
26 West Martin Luther Drive
Cincinnati, OH 45268
513-569-7607
Fax: 513-569-7105

TECHNOLOGY DEVELOPER CONTACTS:

Nick Kolak
New York State Department of
Environmental Conservation
50 Wolf Road, Room 268
Albany, NY 12233-7010
518-457-3372
Fax: 518-457-7743

Richard Cronce
R.E. Wright Environmental, Inc.
3240 Schoolhouse Road
Middletown, PA 17057-3595
717-944-5501
Fax: 717-944-4044

NORTH AMERICAN TECHNOLOGIES GROUP, INC. (Oleophilic Amine-Coated Ceramic Chip)

TECHNOLOGY DESCRIPTION:

This hydrocarbon recovery technology is based on an oleophilic, amine-coated ceramic chip that separates suspended and dissolved hydrocarbons, as well as most mechanical and some chemical emulsions, from aqueous solutions. The oleophilic chip is manufactured by grafting a hydrophobic amine to a mineral support, in this case a ceramic substrate. Each granule is 0.6 to 1 millimeter in diameter, but is very porous and thus has a large surface area. The hydrophobic property of the amine coating makes each granule more effective for microfiltration of hydrocarbons in an unstable emulsion.

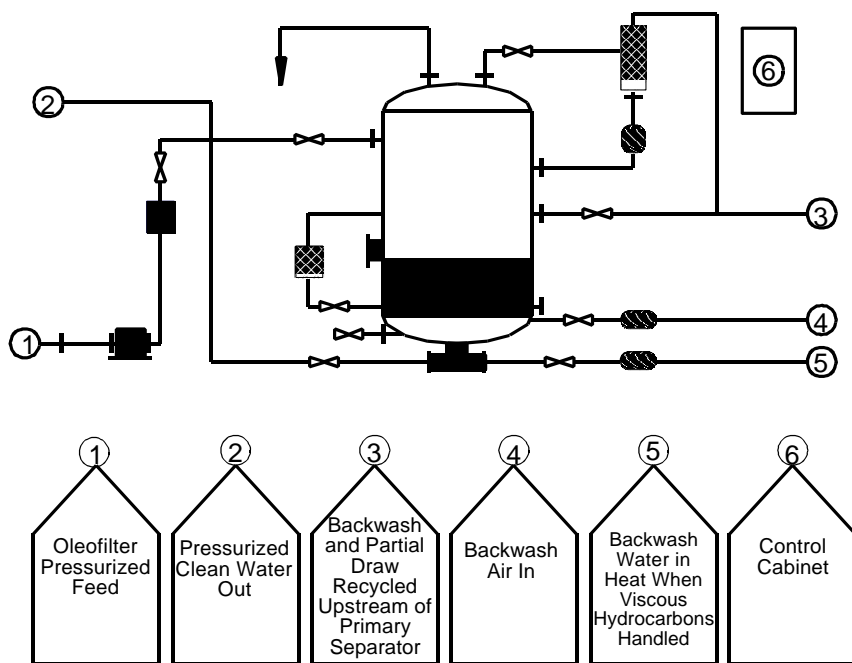
The figure below illustrates the process; the separator, filter, and coalescer unit is shown on the next page. The pressure-sensitive filtering bed is regenerated by automatic backflushing. This automatic regeneration eliminates the expense associated with regeneration of carbon and similar filtration media. Recovered hydrocarbons coalesce and can thus be removed by simple gravity separation.

This technology provides cost-effective oil and water separation, removes free and emulsified hydrocarbon contaminants, and significantly reduces hydrocarbon loading to air strippers and carbon systems. The technology can achieve a concentration of less than 7 parts per million oil and grease in the treated effluent.

WASTE APPLICABILITY:

The amine-coated granules have proven effective on a wide variety of hydrocarbons, including gasoline; crude oil; diesel fuel; benzene, toluene, ethylbenzene and xylene mixtures; and polynuclear aromatic hydrocarbons. The unit also removes hydrophobic chlorinated hydrocarbons such as pentachlorophenol, polychlorinated biphenyls, and trichloroethene, as well as vegetable and animal oils.

Treatment systems incorporating this technology have been designed for various applications, including (1) contaminated groundwater pump-and-treat systems; (2) in-process oil and water separation; (3) filtration systems; (4) combined oil and water separator-filter-coalescer systems for on-



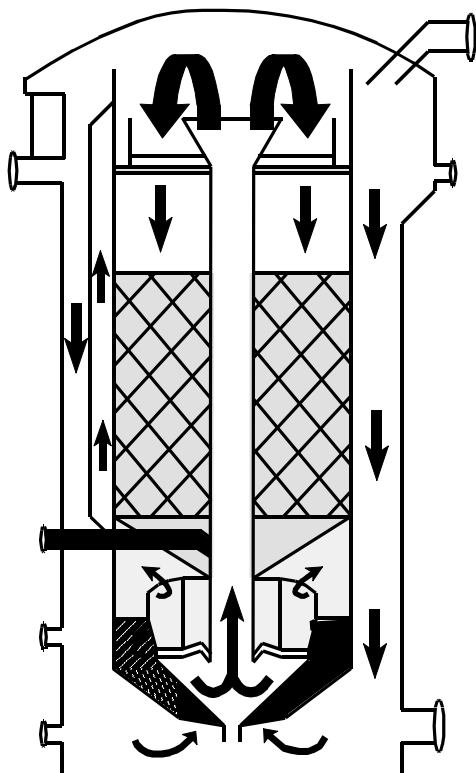
Schematic Diagram of the Oleofilter Technology

site waste reduction and material recovery; and (5) treatment of marine wastes (bilge and ballast waters).

STATUS:

This technology was accepted into the SITE Demonstration Program in December 1992. The SITE demonstration was completed in June 1994 at the Petroleum Products Corporation site in Fort Lauderdale, Florida. The site is a former oil recycling facility where groundwater has been contaminated with a variety of organic and inorganic constituents. The Demonstration Bulletin (EPA/540/MR-94/525) and Innovative Technology Evaluation Report (EPA/540/R-94/525) are available from EPA.

The technology has been used for several full-scale projects. Several separator-filter-coalescers (see figure below) are in use treating industrial process waters and oily wash waters.



Separator, Filter, and Coalescer

DEMONSTRATION RESULTS:

For the demonstration, five separate evaluation periods (runs) were initiated. Each run used the same feed oil, except run four. The oil for run four was a 3:1 mixture of oil to kerosene. The average total recoverable petroleum hydrocarbon (TRPH) concentrations for the feed streams ranged from 422 to 2,267 milligrams per liter (mg/L). Preliminary data indicate that the system removed at least 90 percent of the TRPH from the emulsified oil and water feed stream.

For the runs where the system operated within normal design parameters, TRPH concentrations in the treated water effluent were reduced to 15 mg/L or less. The oleophilic granules achieved a 95 percent reduction of TRPH concentration for the runs with similar feed oil.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Laurel Staley
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7863
Fax: 513-569-7620

TECHNOLOGY DEVELOPER CONTACT:

Alan Bell
North American Technologies Group, Inc.
4710 Bellaire Boulevard, Suite 301
Bellaire, TX 77401
713-662-2699
Fax: 713-662-3728

NOVATERRA ASSOCIATES

(In Situ Soil Treatment [Steam and Air Stripping])

TECHNOLOGY DESCRIPTION:

This technology treats contaminated soils and contained groundwater by the simultaneous in situ injection of treatment agents below ground during active mixing by augers or drilling blades (see figure below). The in situ injection of steam and air during mixing strips the volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) from the soil and contained groundwater. The removed organics are captured at the surface and disposed of in an environmentally safe manner.

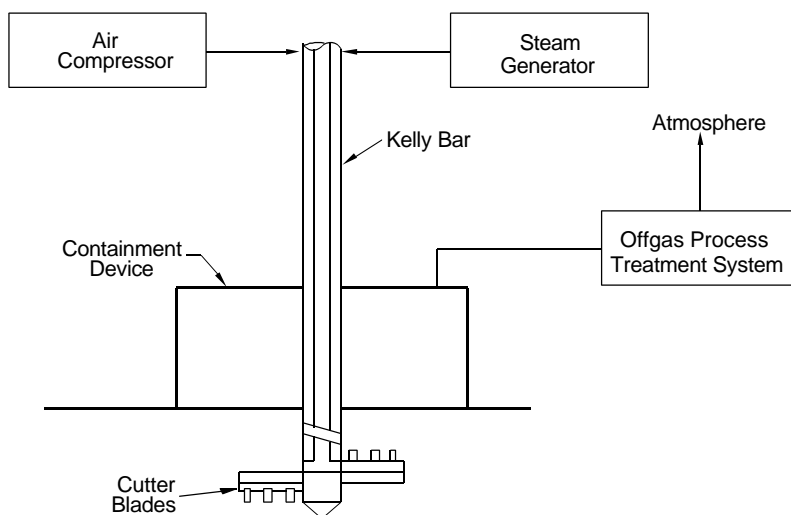
The technology is implemented by a drill unit that can consist of a single or double blade or auger mounted on a large crane or backhoe. The diameter of the drill or auger can vary from 5 to 8 feet, and it is mounted on a kelly that reaches depths of 60 feet.

The steam and air are carried down the center of the kelly(s) and injected into the ground through jets located on the blade or auger arms. The steam is supplied by an oil- or natural gas-fired boiler at 450 °F and 500 pounds per square inch gauge (psig). The air heated by the compressor is injected at 250 °F and 200 psig. The steam heats the contaminants in the soil and contained water, increasing the vapor pressure of the VOCs and SVOCs and increasing their removal rates. The direct application of the

steam on the soil thermally desorbs the VOCs and SVOCs, increasing their removal percentage. Almost all the VOCs and SVOCs of interest form azeotropes with steam that boil below 212 °F and contain low concentrations (such as a few percent) of contaminants. These azeotropes significantly increase contaminant removal rates, especially for the higher-boiling-point SVOCs.

The VOC- and SVOC-laden air and steam vapor stream removes the contamination to the surface where it can be captured, if necessary, in a metal container. The container, which makes a tight seal to the ground surface, is connected to a process stream by piping. A suction blower draws the waste stream to the process stream where it is collected or destroyed. The blower creates a slight vacuum in the container and piping as well as a positive displacement inward to the collection or destruction system, thus protecting the outside environment from contamination.

The simplest form of the process system uses a catalytic oxidizer or thermal oxidizer to destroy the contamination before exhausting to the atmosphere. When treating chlorinated VOCs and SVOCs, an acid scrubber can be added if required by the amount of material being processed. Another simple process uses activated carbon to recover the contamination. For the carbon to work efficiently,



In Situ Soil Treatment Process Schematic

a cooling system must precede the carbon bed, so the process must also treat contaminated water. If recovery and reuse of the contamination is important or economically desirable, a process system that condenses the gas stream can be used.

The in situ soil treatment technology has also treated contaminated soil by injecting and mixing other agents. Chemical injection processes include the stabilization and solidification of heavy metals, neutralization of acids and bases, and oxidation. The technology has been successfully used to perform bioremediation. The equipment is capable of injecting cement into the soil and making slurry walls. The technology has the unique feature of being able to inject two materials simultaneously or sequentially.

WASTE APPLICABILITY:

This technology can treat solid materials which do not contain obstructions, including soils, sludges, lagoons, and the liquids contained within, such as water and dense and light nonaqueous-phase liquids. The technology is applicable to most VOCs and SVOCs, including pesticides. It is particularly applicable to free product and removal of highly concentrated contamination. It is most effective for removals of 95 to 99 percent of the contamination as a result of the low temperature thermal desorption. After treatment is completed, the soil can meet construction engineering requirements by compacting or injecting small amounts of cement.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1989. A SITE demonstration was performed in September 1989 at the Annex Terminal, San Pedro, California. Twelve soil blocks were treated for VOCs and SVOCs. Liquid samples were collected during the demonstration, and the operating procedures were closely monitored and recorded. In January 1990, six blocks that had been previously treated in the saturated zone were analyzed by EPA methods 8240 and 8270.

The Applications Analysis Report (EPA/540/A5-90/008) was published in June 1991. The technology remediated 30,000 cubic yards at the Annex Terminal after completion of the SITE demonstration and has been used at five other contaminated sites.

DEMONSTRATION RESULTS:

The SITE technology demonstration yielded the following results:

- Removal efficiencies were greater than 85 percent for VOCs present in the soil.
- Removal efficiencies were greater than 55 percent for SVOCs present in the soil.
- Fugitive air emissions from the process were low.
- No downward migration of contaminants resulted from the soil treatment.
- The process treated 3 cubic yards of soil per hour.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Paul dePercin
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7797
Fax: 513-569-7105
E-Mail: dePercin.Paul@epamail.epa.gov

TECHNOLOGY DEVELOPER CONTACT:

Phil La Mori
NOVATERRA Associates
2419 Outpost Drive
Los Angeles, CA 90068-2644
213-969-9788
Fax: 213-969-9782
E-mail: NOVATERRA@aol.com

OHM REMEDIATION SERVICES CORP.
(formerly CHEMICAL WASTE MANAGEMENT, INC.)
(X*TRAX™ Thermal Desorption)

TECHNOLOGY DESCRIPTION:

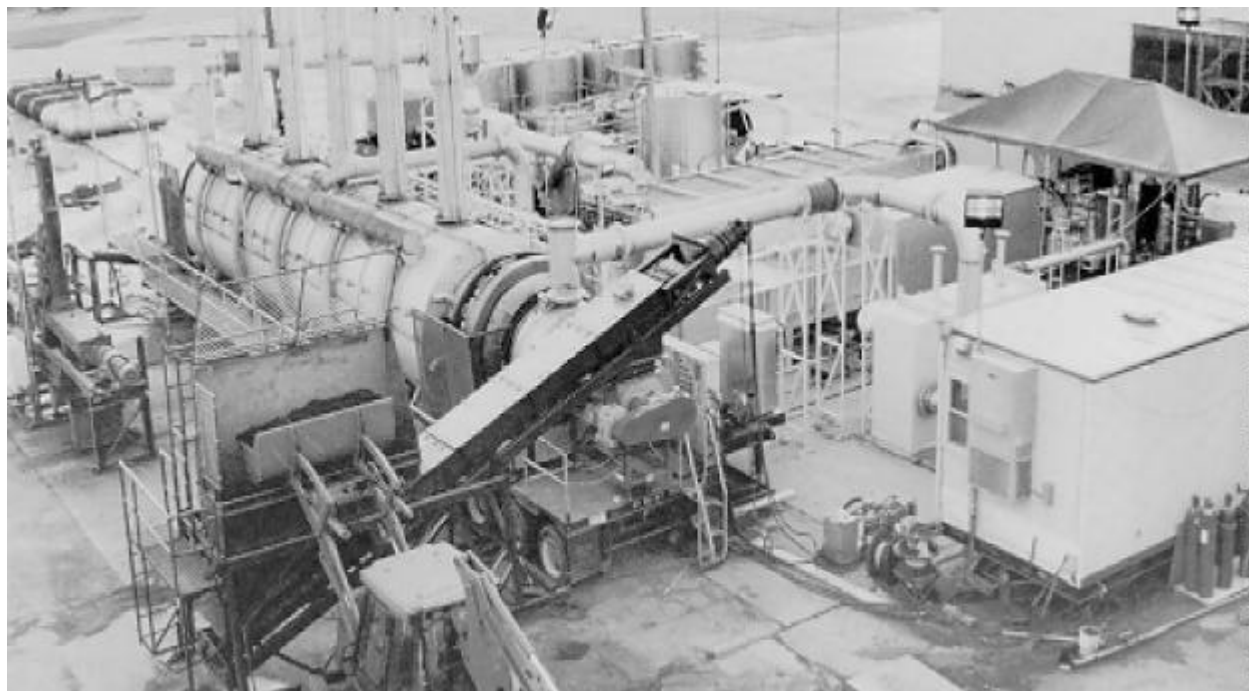
The X*TRAX™ technology is a patented thermal desorption process that removes organic contaminants from soils, sludges, and other solid media (see photograph below). X*TRAX™ is not, however, an incinerator or a pyrolysis system. Chemical oxidation and reactions are discouraged by maintaining an inert environment and low treatment temperatures. Combustion by-products are not formed in X*TRAX™, as neither a flame nor combustion gases are present in the desorption chamber.

The organic contaminants are removed as a condensed liquid, which is characterized by a high heat rating. This liquid may then be destroyed in a permitted incinerator or used as a supplemental fuel. Low operating temperatures of 400 to 1,200 °F and low gas flow rates optimize treatment of contaminated media.

An externally fired rotary dryer volatilizes the water

and organic contaminants from the contaminated media into an inert carrier gas stream. The inert nitrogen carrier gas transports the organic contaminants and water vapor out of the dryer. The carrier gas flows through a duct to the gas treatment system, where organic vapors, water vapors, and dust particles are removed and recovered. The gas first passes through a high-energy scrubber, which removes dust particles and 10 to 30 percent of the organic contaminants. The gas then passes through two condensers in series, where it is cooled to less than 40 °F.

Most of the carrier gas is reheated and recycled to the dryer. About 5 to 10 percent of the gas is separated from the main stream, passed through a particulate filter and a carbon adsorption system, and then discharged to the atmosphere. This discharge allows addition of make-up nitrogen to the system to keep oxygen concentrations below 4 percent (typically below 1 percent). The discharge also helps maintain a small negative pressure within the system and prevents potentially contaminated



Full-Scale X*TRAX™ System

gases from leaking. The volume of gas released from this process vent is approximately 700 times less than from an equivalent capacity incinerator.

WASTE APPLICABILITY:

The X*TRAX™ process has been used to treat solids contaminated with the following wastes: polychlorinated biphenyls (PCB); halogenated and nonhalogenated solvents; semivolatile organic compounds, including polynuclear aromatic hydrocarbons, pesticides, and herbicides; fuel oils; benzene, toluene, ethylbenzene, and xylene; and mercury.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1989. The demonstration was conducted in May 1992 at the Re-Solve, Inc., Superfund site in Massachusetts. After the demonstration, the full-scale X*TRAX™ system, Model 200, remediated 50,000 tons of PCB-contaminated soil at the site. The Demonstration Bulletin (EPA/540/MR-93/502), which details results from the demonstration, is available from EPA.

The full-scale system, Model 200, is presently operating at the Sangamo-Weston Superfund site in South Carolina. More than 45,000 tons of PCB-contaminated soil, clay, and sludge have been thermally treated at this site. Feed material with PCB concentrations of more than 8,800 milligrams per kilogram (mg/kg) has been successfully treated to produce (discharge) PCB levels of less than 2 mg/kg. PCB removal efficiency was demonstrated to be greater than 99.97 percent.

Laboratory-, pilot-, and full-scale X*TRAX™ systems are available. Two laboratory-scale, continuous pilot systems are available for treatability studies. More than 108 tests have been completed since January 1988.

DEMONSTRATION RESULTS:

During the SITE demonstration, X*TRAX™ removed PCBs from feed soil and met the site-specific treatment standard of 25 mg/kg for treated soils. PCB concentrations in all treated soil samples were less than 1.0 mg/kg and were reduced from an average of 247 mg/kg in feed soil to an average of 0.13 mg/kg in treated soil. The average PCB removal efficiency was 99.95 percent.

Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans were not formed within the X*TRAX™ system. Organic air emissions from the X*TRAX™ process vent were negligible (less than 1 gram per day). PCBs were not detected in vent gases.

X*TRAX™ removed other organic contaminants from feed soil. Concentrations of tetrachloroethene, total recoverable petroleum hydrocarbons, and oil and grease were reduced to below detectable levels in treated soil. Metals concentrations and soil physical properties were not altered by the X*TRAX™ system.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Paul dePercin
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7797
Fax: 513-569-7105
E-Mail: dePercin.Paul@epamail.epa.gov

TECHNOLOGY DEVELOPER CONTACT:

Chetan Trivedi
OHM Remediation Services Corp.
100 West 22nd Street, Suite 101
Lombard, IL 60148
630-261-3958
Fax: 630-261-3969

RADIAN INTERNATIONAL LLC
(formerly DOW ENVIRONMENTAL, INC.)
(Integrated Vapor Extraction and Steam Vacuum Stripping)

TECHNOLOGY DESCRIPTION:

The integrated AquaDetox/soil gas vapor extraction/reinjection (SVE) system simultaneously treats groundwater and soil contaminated with volatile organic compounds (VOC). The integrated system consists of (1) an AquaDetox moderate vacuum stripping tower that uses low-pressure steam to treat contaminated groundwater, and (2) an SVE process to treat contaminated soil. The two processes form a closed-loop system that simultaneously remediates contaminated groundwater and soil in situ with virtually no air emissions.

AquaDetox is a high-efficiency, countercurrent stripping technology. A single-stage unit can remove up to 99.99 percent of VOCs in water. The SVE system uses a vacuum to treat VOC-

contaminated soil, inducing a flow of air through the soil and removing vapor-phase VOCs with the extracted soil gas. Carbon beds remove the VOCs from the soil gas, which is then reinjected into the ground. The AquaDetox and SVE systems share a granulated activated carbon (GAC) unit that decontaminates the combined vapors from both systems (see photograph below). By-products of the system are a free-phase recyclable product and treated water. In addition, mineral regenerable carbon will require disposal after about 3 years.

A key element of the closed-loop system is the vent header unit. This unit collects noncondensable gases from the AquaDetox system for treatment in the GAC units. Conversely, the AquaDetox system condenses and treats the steam used to regenerate the GAC units.

WASTE APPLICABILITY:



Integrated AquaDetox/SVE System

This technology removes VOCs, including chlorinated hydrocarbons, in groundwater and soil. Sites with contaminated groundwater and soils containing trichloroethene (TCE), tetrachloroethene (PCE), and other VOCs are suitable for this on-site treatment process.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1990. In September 1990, a SITE demonstration was conducted as part of an ongoing remediation at the San Fernando Valley Groundwater Basin Superfund site in Burbank, California. The Applications Analysis Report (EPA/540/A5-91/002) and Demonstration Bulletin (EPA/540/M5-91/002) are available from EPA.

The AquaDetox/SVE system had been used for over 3 years at the time of the SITE evaluation to treat groundwater and soil gas at the Lockheed Aeronautical Systems Company in Burbank, California. Contaminated groundwater was treated at a rate of up to 1,200 gallons per minute (gpm), while soil gas was removed and treated at a rate of 300 cubic feet per minute. The system occupied about 4,000 square feet. It was operational 95 percent of the time, with 5 percent downtime for scheduled and nonscheduled repairs.

DEMONSTRATION RESULTS:

During the SITE demonstration, the AquaDetox/SVE system achieved the following results:

- The technology treated groundwater and soil gas contaminated with VOCs.
- Efficiencies ranged from 99.92 to 99.99 percent for removal of VOCs from contaminated groundwater. VOC removal efficiencies for soil gas ranged from 98.0 to 99.9 percent when the GAC beds were regenerated according to the specified frequency (8-hour shifts). VOC removal efficiencies dropped to as low as 93.4 percent when the GAC beds were regenerated less frequently.

- The technology produced effluent groundwater that complied with regulatory discharge requirements for TCE and PCE (5 micrograms per liter for each compound).
- The GAC beds removed VOCs from contaminated soil gas even after 24 hours of continuous operation without steam regeneration.
- The system's steam consumption dropped with decreasing tower pressures. During the demonstration, the system was more efficient at lower operating tower pressures.
- The 500-, 1,000-, and 3,000-gpm systems are estimated to cost about \$3.2, \$4.3, and \$5.8 million, respectively. The total annual operation and maintenance costs are about \$410,000, \$630,000 and \$1,500,000 for the 500-, 1,000-, and 3,000-gpm systems, respectively.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Gordon Evans

U.S. EPA

National Risk Management Research
Laboratory

26 West Martin Luther King Drive

Cincinnati, OH 45268

513-569-7684

Fax: 513-569-7787

TECHNOLOGY DEVELOPER CONTACT:

David Bluestein

Radian International LLC

1990 North California Boulevard, Suite 500

Walnut Creek, CA 94596

510-988-1125

Fax: 510-932-7130

REMEDIATION TECHNOLOGIES, INC.

(Liquid and Solids Biological Treatment)**TECHNOLOGY DESCRIPTION:**

Liquid and solids biological treatment (LST) is a process that remediates soils and sludges contaminated with biodegradable organics (see figure below). The process is similar to activated sludge treatment of municipal and industrial wastewaters, but it treats suspended solids concentrations greater than 20 percent. First, an aqueous slurry of the waste material is prepared, and environmental conditions such as nutrient concentrations, temperature, and pH are optimized for biodegradation. The slurry is then mixed and aerated for a sufficient time to degrade the target waste constituents.

Several physical process configurations are possible, depending on site- and waste-specific conditions. Waste can be treated continuously or in batches in impoundment-based reactors. This configuration is sometimes the only practical option for projects greater than 10,000 cubic yards. Alternatively, tank-based systems may be constructed.

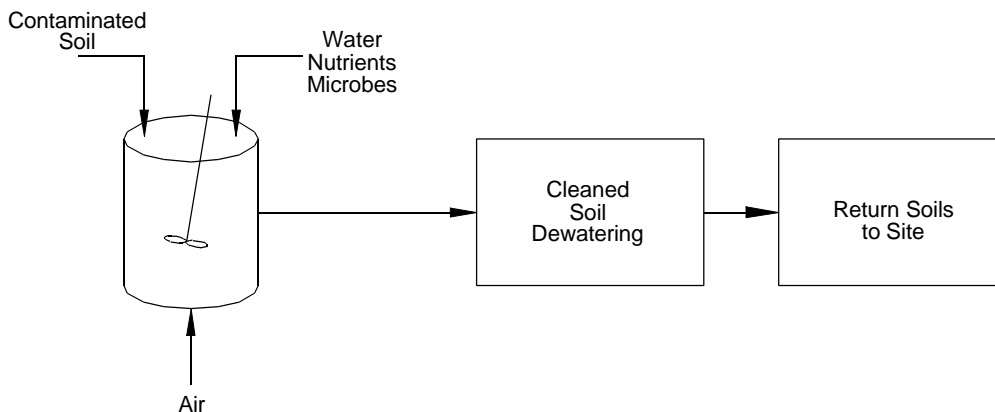
Constituent losses due to volatilization must be

controlled during LST operations. The potential for emissions is greatest in batch treatment systems and lowest in continuously stirred tank reactor systems, particularly those with long residence times. Technologies such as carbon adsorption and biofiltration can control emissions.

LST may require pre- and posttreatment operations. However, in situ applications that store treated sludge residues do not require multiple unit operations.

Overall bioremediation in a hybrid system consisting of LST and land treatment systems can provide an alternative to landfilling treated solids. This combination rapidly degrades volatile constituents in a contained system, rendering the waste suitable for landfilling.

Remediation Technologies, Inc. (ReTeC), has constructed a mobile LST pilot system for field demonstrations. The system consists of two reactors, two 2,000-gallon holding tanks, and associated process equipment. The reactors are aerated using coarse bubble diffusers and mixed



Liquid and Solids Biological Treatment

using axial flow turbine mixers. The reactors can operate separately, or as batch or continuous systems. Oxygen and pH are continuously monitored and recorded. Additional features include antifoaming and temperature control systems.

WASTE APPLICABILITY:

The technology treats sludges, sediments, and soils containing biodegradable organic materials. To date, the process has mainly treated sludges containing petroleum and wood preservative organics such as creosote and pentachlorophenol (PCP). LST has treated polynuclear aromatic hydrocarbons (PAH), PCP, and a broad range of petroleum hydrocarbons in the laboratory and the field.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1987. The technology was demonstrated under SITE at the Niagara Mohawk Power Corporation facility at Harbor Point in Utica, New York from June through August 1995. The following equipment was used for the demonstration: (1) a 10,000-gallon cylindrical tank (12-foot diameter) with bottom-mounted air diffusers that provided aeration and assisted in suspending solids; (2) a tank cover outfitted with exhaust piping that contained and channeled air discharge; and (3) a spray system that recirculated liquid from within the tank to disperse foam buildup.

ReTeC has applied the technology in the field over a dozen times to treat wood preservative sludges with impoundment-type LST systems. In addition, LST has treated petroleum refinery impoundment sludges in two field-based pilot demonstrations and several laboratory treatability studies.

DEMONSTRATION RESULTS:

Analytical results from the SITE demonstration showed a reduction in oil and grease concentrations from 14,500 to 3,100 milligrams per kilogram (mg/kg), or 79 percent; total PAH concentrations were reduced from 137 to 51 mg/kg, or 63 percent; and total benzene, toluene, ethylbenzene, and xylene concentrations were reduced from 0.083 to 0.030 mg/kg, or 64 percent. PAH leachability in the solids was reduced to nondetect levels after treatment. Toxicity of the solids to earthworms was also decreased by the treatment. Only 24 percent of the earthworms survived when added to untreated contaminated soil, while earthworms placed in treated soil showed no toxic effects.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Ronald Lewis
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7856
Fax: 513-569-7105

TECHNOLOGY DEVELOPER CONTACT:

Merv Cooper
Remediation Technologies, Inc.
1011 S.W. Klickitat Way, Suite 207
Seattle, WA 98134
206-624-9349
Fax: 206-624-2839

**RETECH, M4 ENVIRONMENTAL
MANAGEMENT INC.**
(Plasma Arc Vitrification)

TECHNOLOGY DESCRIPTION:

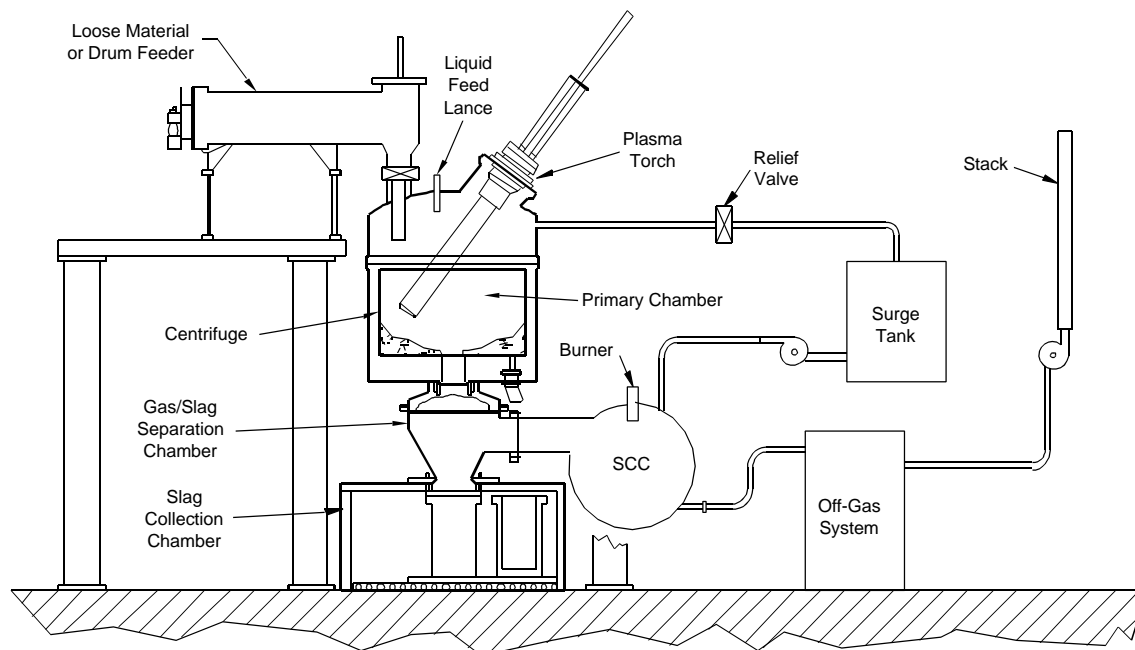
Plasma arc vitrification occurs in a plasma arc centrifugal treatment (PACT) system, where heat from a transferred plasma arc torch creates a molten bath that detoxifies the feed material (see figure below). Solids are melted into the molten bath while organics are evaporated and destroyed. Metallic feed material can either form a separate liquid phase underneath the metal oxide slag layer or can be oxidized and become part of the slag layer.

Waste material is fed into a sealed centrifuge, where a plasma torch heats solids to approximately 3,200 °F and gas headspace to a minimum of 1,800 °F. Organic material is evaporated and destroyed. Off-gases travel through a gas-slag separation chamber to a secondary chamber, where the temperature is maintained at over 2,000 °F for at least 2 seconds. The off-gases then flow through an off-gas treatment system.

Inorganic material is reduced to a molten phase that is uniformly heated and mixed by the centrifuge and the plasma arc. Material can be added in-process to control slag quality. When the centrifuge slows, the molten material is discharged as a homogeneous, nonleachable, glassy slag into a mold or drum in the slag collection chamber. When cooled, the resulting product is a nonleachable, glassy residue which meets toxicity characteristic leaching procedure (TCLP) criteria.

The off-gas treatment system removes particulates, acid gases, and volatilized metals. Off-gas monitoring verifies that all applicable environmental regulations are met. The design of the off-gas treatment system depends on the waste material.

The entire system is hermetically sealed and operated below atmospheric pressure to prevent leakage of process gases. Pressure relief valves connected to a closed surge tank provide relief if



Plasma Arc Centrifugal Treatment (PACT) System

gas pressures in the system exceed safe levels. Vented gas is held in the tank, then recycled through the PACT system.

WASTE APPLICABILITY:

The technology can process organic and inorganic solid and liquid wastes. It is most appropriate for mixed, transuranic, and chemical plant wastes; soil containing both heavy metals and organics; incinerator ash; and munitions, sludge, and hospital waste.

Waste may be loose (shredded or flotation process) or contained in 55-gallon drums. It can be in almost any physical form: liquid, sludge, metal, rock, or sand. Volatile metals in the waste, such as mercury, are recovered by the off-gas treatment system.

STATUS:

The PACT-6 System, formerly PCF-6, was demonstrated under the SITE Program in July 1991 at the Component Development and Integration Facility of the U.S. Department of Energy in Butte, Montana. During the demonstration, about 4,000 pounds of waste was processed. The waste consisted of heavy metal-bearing soil from Silver Bow Creek Superfund site spiked with 28,000 parts per million (ppm) of zinc oxide, 1,000 ppm of hexachlorobenzene, and a 90-to-10 weight ratio of No. 2 diesel oil. All feed and effluent streams were sampled. The Demonstration Bulletin (EPA/540/M5-91/007), Applications Analysis Report (EPA/540/A5-91/007), and Technology Evaluation Report (EPA/540/5-91/007b) are available from EPA.

During subsequent testing at the Component Development and Integration Facility, the PACT-6 system achieved the following results:

- Hexachlorobenzene was at or below detection limits in all off-gas samples. The minimum destruction removal efficiency ranged from 99.9968 percent to greater than 99.9999 percent.
- The treated material met TCLP standards for organic and inorganic constituents.

- Particulates in the off-gas exceeded the regulatory standard. The off-gas treatment system is being modified accordingly. Particulate emissions from another PACT-8 system in Switzerland were measured at 1/200th of the U.S. regulatory limit.
- Nitrous oxide (NO_x) levels were very high during the demonstration, but can meet stricter standards. While NO_x concentrations during the demonstration exceeded 5,000 ppm, the NO_x concentrations in the off-gas from the PACT-8 furnace in Switzerland was reduced to 19 ppm.

Two PACT-2 systems are in use in Europe, while three PACT-8 systems are under construction for European and domestic nuclear and commercial applications. Two PACT-1 bench-scale systems are also in domestic use for nuclear and shipboard testing.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Laurel Staley
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7863
Fax: 513-569-7620

TECHNOLOGY DEVELOPER CONTACTS:

Ronald Womack or Leroy Leland
Retech, M4 Environmental Management Inc.
P.O. Box 997
100 Henry Station Road
Ukiah, CA 95482
707-462-6522
Fax: 707-462-4103

ROCHEM SEPARATION SYSTEMS, INC. (Rochem Disc Tube™ Module System)

TECHNOLOGY DESCRIPTION:

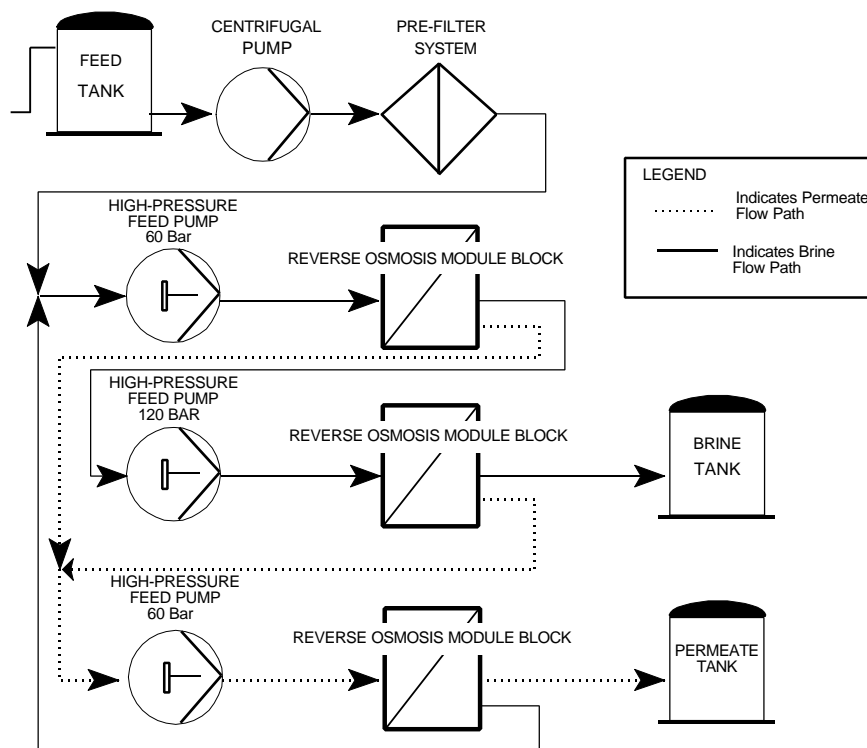
The Rochem Disc Tube™ Module System uses membrane separation to treat aqueous solutions ranging from seawater to leachate contaminated with organic solvents. The system uses osmosis through a semipermeable membrane to separate pure water from contaminated liquids.

Osmotic theory implies that a saline solution may be separated from pure water by a semipermeable membrane. The higher osmotic pressure of the salt solution causes the water (and other compounds having high diffusion rates through the selected membrane) to diffuse through the membrane into the salt water. Water will continue to permeate the salt solution until the osmotic pressure of the salt solution equals the osmotic pressure of the pure water. At this point, the salt concentrations of the two solutions are equal, eliminating any additional driving force for mass transfer across the membrane.

However, if external pressure is exerted on the salt solution, water will flow in the reverse direction from the salt solution into the pure water.

This phenomenon, known as reverse osmosis (RO), can separate pure water from contaminated matrices. RO can treat hazardous wastes by concentrating the hazardous chemical constituents in an aqueous brine, while recovering pure water on the other side of the membrane.

Fluid dynamics and system construction result in an open-channel, fully turbulent feed and water-flow system. This configuration prevents accumulation of suspended solids on the separation membranes, ensuring high efficiency filtration for water and contaminants. Also, the design of the disc tubes allows easy cleaning of the filtration medium, providing a long service life for the membranes.



Three-Stage, Reverse Osmosis Flow Path

A general flow path for the Rochem Disc Tube™ Module System as applied at the SITE demonstration is shown on the previous page. Waste feed, process permeate, and rinse water are potential feed materials to the RO modules. The modules are skid-mounted and consist of a tank and a high-pressure feed system. The high-pressure feed system consists of a centrifugal feed pump, a prefilter cartridge housing, and a triplex plunger pump to feed the RO modules. The processing units are self-contained and require electrical and interconnection process piping before operation.

WASTE APPLICABILITY:

Many types of waste material can be treated with this system, including sanitary and hazardous landfill leachate containing both organic and inorganic chemical species.

STATUS:

This technology was accepted into the SITE Demonstration Program in July 1991. The demonstration was conducted in August 1994 at the Central Landfill Superfund site in Johnston, Rhode Island. The system was used to treat landfill leachate from a hazardous waste landfill. During the demonstration, approximately 4 gallons per minute of contaminated waste was processed over a 3-week period. All feed and residual effluent streams were sampled to evaluate the performance of this technology. The Innovative Technology Evaluation Report (EPA/540/R-96/507), the Technology Capsule (EPA/540/R-96/507a), and the Demonstration Bulletin (EPA/540/MR-96/507) are available from EPA.

DEMONSTRATION RESULTS:

Preliminary results from the demonstration suggest the following:

- Over 99 percent of total dissolved solids, over 96 percent of total organic carbon, and 99 percent of all target metals were removed. In addition, the average percent rejection for volatile organic compounds was greater than the test criteria of 90 percent.
- The average water recovery rate for the Rochem Disc Tube™ Module System during the demonstration was approximately 75 percent. The test criterion was 75 percent treated water recovery rate.
- The Rochem Disc Tube™ Module System operated for 19 days at up to 8 hours per day. Daily operation hours were not as long as planned due to weather and field operational difficulties. However, the system operated long enough to evaluate the technology's performance.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Douglas Grosse
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7844
Fax: 513-569-7585

TECHNOLOGY DEVELOPER CONTACT:

David LaMonica
Rochem Separation Systems, Inc.
3904 Del Amo Boulevard, Suite 801
Torrance, CA 90503
310-370-3160
Fax: 310-370-4988

SBP TECHNOLOGIES, INC.
(Membrane Filtration and Bioremediation)

TECHNOLOGY DESCRIPTION:

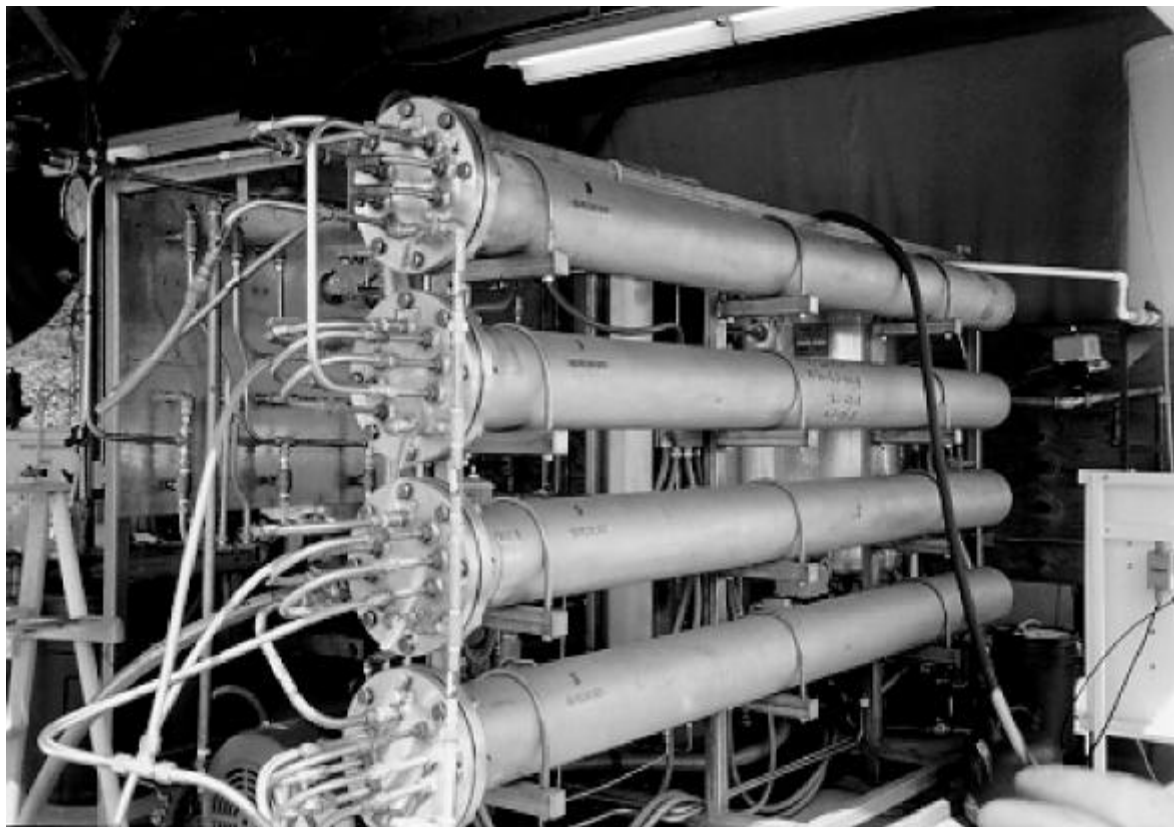
SBP Technologies, Inc. (SBP), has developed a hazardous waste treatment system consisting of (1) a membrane filtration system that extracts and concentrates contaminants from groundwater, surface water, wash water, or slurries; and (2) a bioremediation system that treats concentrated groundwater, wash water, and soil slurries (see photograph below). These two systems treat a wide range of waste materials separately or as parts of an integrated waste handling system.

The membrane filtration system removes and concentrates contaminants by pumping contaminated liquids through porous stainless steel tubes coated with specifically formulated membranes. Contaminants are collected inside the tube membrane, while "clean" water permeates the

membrane and tubes. Depending on local requirements and regulations, the clean permeate can be discharged to the sanitary sewer for further treatment at a publicly owned treatment works (POTW). The concentrated contaminants are collected in a holding tank and fed to the bioremediation system.

Contaminated water or slurry can also flow directly into the bioremediation system and be polished in the membrane filtration system. The bioremediation system consists of one or more bioreactors that are inoculated with specially selected, usually indigenous microorganisms to produce effluent with low to nondetectable contaminant levels. Integrating the two systems allows removal and destruction of many contaminants.

WASTE APPLICABILITY:



Membrane Filtration and Bioremediation

The membrane filtration system concentrates contaminants and reduces the volume of contaminated materials from a number of waste streams, including contaminated groundwater, surface water, storm water, landfill leachates, and industrial process wastewater.

The bioremediation system can treat a wide range of organic contamination, especially wood-preserving wastes and solvents. A modified version can also treat polynuclear aromatic hydrocarbons (PAH) such as creosote and coal tar; pentachlorophenol; petroleum hydrocarbons; and chlorinated aliphatics, such as trichloroethene.

The two technologies can be used separately or combined, depending on site characteristics and waste treatment needs. For example, for wastewaters or slurries contaminated with inorganics or materials not easily bioremediated, the membrane filtration system can separate the material for treatment by another process. Both the membrane filtration system and the bioremediation system can be used as part of a soil cleaning system to handle residuals and contaminated liquids.

STATUS:

The membrane filtration system, accepted into the SITE Program in 1990, was demonstrated in October 1991 at the American Creosote Works in Pensacola, Florida. The Demonstration Bulletin (EPA/540/MR-92/014) and Applications Analysis Report (EPA/540/AR-92/014) are available from EPA. A full-scale SITE Program demonstration of the bioremediation system was canceled. However, a smaller-scale field study was conducted at the site; results are available through the developer.

SBP is marketing its bioremediation and membrane filtration systems to industrial and governmental clients for on-site treatment of contaminated soil, sludge, and water.

DEMONSTRATION RESULTS:

Results from the SITE demonstration are summarized as follows:

- The system effectively concentrated the PAHs into a smaller volume.
- The process removed 95 percent of the PAHs found in creosote from the feed and produced a permeate stream that was acceptable for discharge to a POTW.
- The membrane removed 25 to 35 percent of smaller phenolic compounds.
- The system removed an average of about 80 percent of the total concentrations of creosote constituents (phenolics and PAHs) in the feedwater and permeate.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

John Martin
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7758
Fax: 513-569-7620

TECHNOLOGY DEVELOPER CONTACT:

Clayton Page
SBP Technologies, Inc.
6149 North Shore Drive
Baton Rouge, LA 70817
504-755-7711
Fax: 504-755-7711

J.R. SIMPLOT COMPANY
(The SABRE™ Process)

TECHNOLOGY DESCRIPTION:

The patented Simplot Anaerobic Biological Remediation (SABRE™) process reduces contamination through on-site bioremediation of soils contaminated with the herbicide dinoseb (2-*sec*-butyl-4,6-dinitrophenol) or nitroaromatic explosives. The biodegradation process begins when contaminated soil is placed in a bioreactor and flooded with buffered water. A source of carbon and a nitroaromatic-degrading consortium of anaerobic bacteria are then added to the bioreactor. Anaerobic conditions are quickly established, allowing the bacteria to degrade the target compounds while preventing polymerization of intermediate breakdown products. A photograph of the technology in operation is shown below.

Soil can be treated in above- or in-ground containment ponds. Temperature, pH, and redox potential in the bioreactor are monitored during treatment. A hydromixing system has been

engineered to efficiently solubilize the target compound from the soil while maintaining anaerobic conditions. Frequency of mixing depends upon the contaminants present, concentration, soil heterogeneity, and soil type.

WASTE APPLICABILITY:

This technology is designed to treat soils contaminated with nitroaromatic pesticides and explosives. This contamination most often occurs at rural crop dusting aircraft sites and at ordnance handling and manufacturing facilities.

STATUS:

This technology was accepted into the SITE Emerging Technology Program in January 1990. Based on bench- and pilot-scale results from the Emerging Technology Program, this technology was accepted in the SITE Demonstration Program in winter 1992. Demonstrations for dinoseb and the



Bioreactors and Soil Mixing System at a TNT-Contaminated Site in Bangor, Washington

explosive TNT (2,4,6-trinitrotoluene) were performed at Bowers Field in Ellensburg, Washington and at Weldon Spring Ordnance Works in Weldon Spring, Missouri, respectively. A Technology Capsule describing the dinoseb project (EPA/540/R-94/508a) and an Innovative Technology Evaluation Report describing the TNT project (EPA/540/R-95/529) are available from EPA.

Since then, the process has been evaluated at several other sites. During the winters of 1994 and 1995, two 10-cubic-yard (yd³) batches of soils from Bangor Naval Submarine Base, Washington were treated using the SABRE™ Process. One batch contained TNT, while the other was contaminated with TNT and RDX. Cost savings were realized by using in-ground ponds for bioreactors and efficient mixing. Heaters were also installed to maintain optimum biological activity during the sub-freezing temperatures. Treatment goals were met or surpassed in the 90 days allowed for the project.

A full-scale remediation of 321 yd³ of dinoseb-contaminated soils was completed in October 1995. The site was a former herbicide distributor located near Reedley, California. The treatment was performed in an aboveground containment already existing on site. Concentrations ranging from 40 to 100 milligrams per kilogram were reduced to nondetect after 28 days of treatment. The soil was mixed three times during treatment using a full-scale, expandable hydromixing system.

A larger evaluation was conducted in fall 1996 at Naval Weapons Station - Yorktown. About 500 yd³ of soil were contained in an in-ground pond measuring 86 feet by 150 feet deep. A full-scale hydromixing system was used to periodically slurry the soil and water mixture.

Process optimization work is ongoing. Collaborative projects with the U.S. Army Corps of Engineers Waterways Experiment Station and the U.S. Army Environmental Center are underway.

DEMONSTRATION RESULTS:

During the Weldon Spring demonstration, TNT was reduced from average concentrations of 1,500 parts

per million (ppm) to an average of 8.7 ppm, for an average removal rate of 99.4 percent. Toxicity testing, which included early seedling growth, root elongation, and earthworm reproduction tests, showed that soil toxicity was significantly reduced. The Weldon Spring demonstration showed the effectiveness of this process even in unfavorable conditions. The treatment time was lengthened by unseasonably cool ambient temperatures. Temperatures in the bioreactor were as low as 4 °C; ideal temperatures for the SABRE™ process are 35 to 37 °C.

During the Ellensburg demonstration, dinoseb was reduced from 27.3 ppm to below the detection limit, a greater than 99.8 percent removal. Other pesticides were also degraded in this process, highlighting the effectiveness of the process even in the presence of co-contaminants. The process was completed in just 23 days, despite 18 °C temperatures.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Wendy Davis-Hoover
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7206
Fax: 513-569-7879

TECHNOLOGY DEVELOPER CONTACTS:

Russell Kaake or Tom Yergovich
J.R. Simplot Company
P.O. Box 912
Pocatello, ID 83201
208-235-5620 or 208-238-2850
Fax: 208-235-5699

**SMITH ENVIRONMENTAL
TECHNOLOGIES CORPORATION**
(formerly CANONIE ENVIRONMENTAL SERVICES CORPORATION)
(Low Temperature Thermal Aeration [LTTA®])

TECHNOLOGY DESCRIPTION:

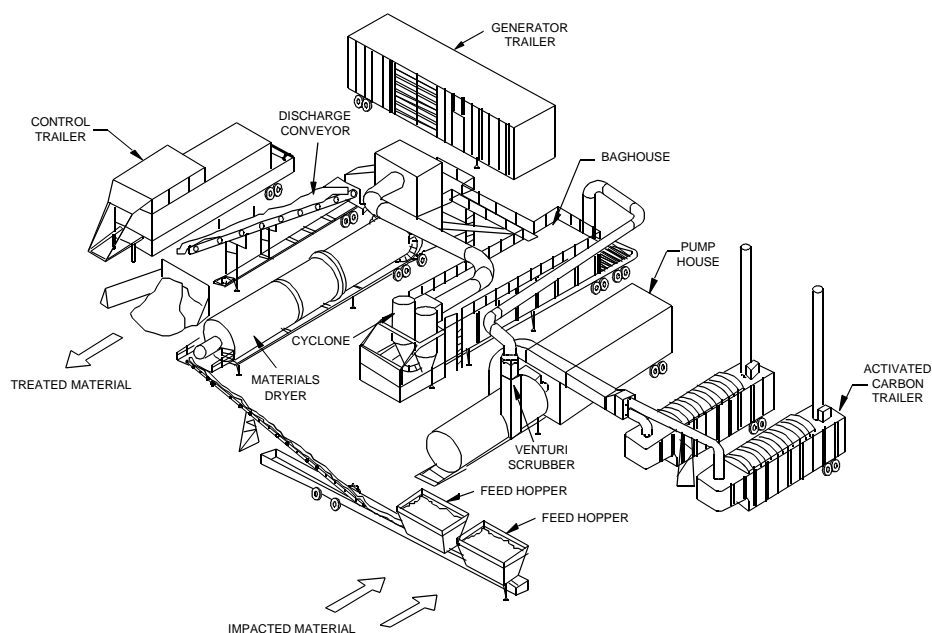
The Low Temperature Thermal Aeration (LTTA®) technology is a low-temperature desorption process (see figure below). The technology removes organic contaminants from contaminated soils into a contained air stream, which is extensively treated to collect or thermally destroy the contaminants.

A direct-fired rotary dryer heats an air stream which, by direct contact, desorbs water and organic contaminants from the soil. Soil can be heated to up to 800 °F. The processed soil is quenched to reduce temperatures and mitigate dust problems. The processed soil is then discharged into a stockpile. The hot air stream that contains vaporized water and organics is treated by one of two air pollution control systems. One system removes the organic contaminants from the air stream by adsorption on granular activated carbon (GAC) and includes the following units in series: (1) cyclones and

baghouse for particulate removal; (2) wet scrubber for acid gas and some organic vapor removal; and (3) GAC adsorption beds for organic removal.

The second air pollution control system can treat soils containing high concentrations of petroleum hydrocarbons. The system includes the following units in series: (1) cyclones for particle removal; (2) thermal oxidizer-afterburner for destruction of organics; (3) quench tower for cooling of air stream; (4) baghouse for additional particle removal; and (5) wet scrubber for acid gas removal.

The LTTA® technology generates no wastewater or waste soils. Cyclone fines and baghouse dust are combined with treated soil and quenched with treated scrubber water. The treated soil, once verified to meet the treatment criteria, is backfilled on site without restrictions. GAC beds used for air pollution control are regenerated or incinerated when spent.



Low Temperature Thermal Aeration (LTTA®) Technology

WASTE APPLICABILITY:

LTТА® can remove volatile organic compounds (VOC), semivolatile organic compounds (SVOC), organochlorine pesticides (OCP), organophosphorus pesticides (OPP), and total petroleum hydrocarbons (TPH) from soils, sediments, and some sludges. LTТА® has been used at full scale to remove VOCs such as benzene, toluene, tetrachloroethene, trichloroethene, and dichloroethene; SVOCs such as acenaphthene, chrysene, naphthalene, and pyrene; OCPs such as DDT, DDT metabolites, and toxaphene; OPPs such as ethyl parathion, methyl parathion, merphos, and mevinphos; and TPHs.

STATUS:

The LTТА® technology was accepted into the SITE Demonstration Program in summer 1992. LTТА® was demonstrated in September 1992 on soils contaminated with OCPs during a full-scale remediation at a pesticide site in Arizona. The Demonstration Bulletin (EPA/540/MR-93/504) and Applications Analysis Report (EPA/540/AR-93/504) are available from EPA.

The full-scale LTТА® system has remediated contaminated soils at six sites, including three Superfund sites. The system has treated more than 117,000 tons of soil.

DEMONSTRATION RESULTS:

Key findings from the demonstration are summarized below:

- The LTТА® system achieved the specified cleanup criteria for the site, a sliding scale correlating the concentrations of DDT family compounds (DDT, DDE, and DDD) with concentrations of toxaphene. The maximum allowable pesticide concentrations in the treated soil were 3.52 milligrams per kilogram (mg/kg) of DDT family compounds and 1.09 mg/kg of toxaphene.
- Residual levels of all the pesticides in the treated soil were generally below or close to the laboratory detection limit, with the exception of 4,4'-DDE, which was found at

residual concentrations of 0.1 to 1.5 mg/kg. Removal efficiencies for pesticides found in the feed soil at quantifiable concentrations are summarized below:

<u>Compound</u>	<u>Efficiency</u>
4,4'-DDD	>99.97%
4,4'-DDE	90.26%
4,4'-DDT	99.97%
Endrin	>99.85%
Toxaphene	>99.83%
Endosulfan 1	>99.98%

- The LTТА® process did not generate dioxins or furans as products of incomplete combustion or thermal transformation.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Paul dePercin
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7797
Fax: 513-569-7105
E-Mail: dePercin.Paul@epamail.epa.gov

TECHNOLOGY DEVELOPER CONTACT:

Joseph Hutton
Smith Environmental Technologies Corporation
304 Inverness Way South, Suite 200
Englewood, CO 80112
303-790-1747
Fax: 303-799-0186

SOILTECH ATP SYSTEMS, INC. (Anaerobic Thermal Processor)

TECHNOLOGY DESCRIPTION:

The SoilTech ATP Systems, Inc. (SoilTech), anaerobic thermal processor (ATP) uses a rotary kiln to desorb, collect, and recondense contaminants or recyclable hydrocarbons from a wide variety of feed material (see figure below).

The proprietary kiln contains four separate internal thermal zones: preheat, retort, combustion, and cooling. In the preheat zone, water and volatile organic compounds (VOC) are vaporized. The hot solids and heavy hydrocarbons then pass through a proprietary sand seal to the retort zone. The sand seal allows solids to pass and inhibits gas and contaminant movement from one zone to the other. Concurrently, hot treated soil from the combustion zone enters the retort zone through a second sand seal. This hot treated soil provides the thermal energy necessary to desorb the heavy organic contaminants. The vaporized contaminants are removed under slight vacuum to the gas handling system. After cyclones remove dust from the gases, the gases are cooled, and condensed oil and water are separated into their various fractions.

The coked soil passes through a third sand seal from the retort zone to the combustion zone. Some of the hot treated soil is recycled to the retort zone through the second sand seal as previously described. The remainder of the soil enters the cooling zone. As the

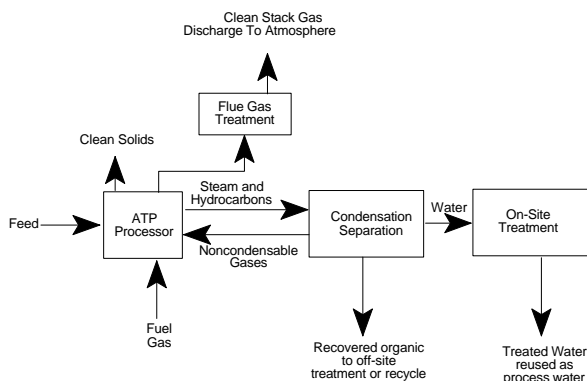
hot combusted soil enters the cooling zone, it is cooled in the annular space between the outside of the preheat zone and the kiln shell. Here, the heat from the combusted soils is transferred indirectly to the soils in the preheat zone. The cooled, treated soil exiting the cooling zone is quenched with water and conveyed to a storage pile.

Flue gases from the combustion zone pass through the cooling zone to an emission control system. The system consists of a cyclone and baghouse to remove particulates, a wet scrubber to remove acid gases, and a carbon adsorption bed to remove trace organic compounds.

WASTE APPLICABILITY:

The system treats soils, sediments, and sludges contaminated with compounds that vaporize at temperatures up to 1,100 °F. Treated solids are free of organics and suited for backfill on site. Applicable contaminants include the following:

- Petroleum hydrocarbons: fuel, oil, lube oil, semivolatile organic compounds (SVOC), VOCs
- Halogenated hydrocarbons: polychlorinated biphenyls (PCB), dioxins, furans, pesticides, herbicides



Anaerobic Thermal Processor (ATP)

- Aromatic hydrocarbons: coal tar residues, polynuclear aromatic hydrocarbons (PAH)
- Volatile metals: mercury

STATUS:

This technology was accepted into the SITE Demonstration Program in 1991. The ATP has been demonstrated at two sites. At the first demonstration, in May 1991, a full-scale unit dechlorinated PCB-contaminated soil at the Wide Beach Development Superfund site in Brant, New York. At the second demonstration, completed in June 1992, a full-scale unit remediated soils and sediments at the Waukegan Harbor Superfund site in Waukegan, Illinois. Two additional Superfund sites in Ohio and Kentucky have since been remediated by the ATP. Soils at these sites were contaminated with PCBs, PAHs, and pesticides.

The ATP has been used to treat more than 100,000 tons of waste on four separate sites. The system has operated in compliance with state and federal regulations in New York, Illinois, Ohio, and Kentucky. SoilTech is currently negotiating with a confidential client to remediate 25,000 cubic yards of trichloroethene- (TCE) and PCB-contaminated soil at a site located in Pennsylvania.

SoilTech is continuing its research into more diverse organic remediation applications and bitumen recovery.

DEMONSTRATION RESULTS:

Test results from both SITE demonstrations indicate the following:

- The SoilTech ATP removed over 99 percent of the PCBs in the contaminated soil, resulting in PCB levels below 0.1 part per million (ppm) at the Wide Beach Development site and averaging 2 ppm at the Waukegan Harbor site.
- Dioxin and furan stack gas emissions were below the site-specific standards.
- PCB stack gas emissions were equivalent to 99.99 percent destruction and removal efficiency at the Waukegan Harbor site.

- No volatile or semivolatile organic degradation products were detected in the treated soil. Also, no leachable metals, VOCs, or SVOCs were detected in the treated soil.
- For the Wide Beach Development and Waukegan Harbor remediation projects, soil treatment costs were approximately \$265 and \$155 per ton, respectively. The regulatory support, mobilization, startup, and demobilization costs totaled about \$1,400,000 for each site.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Paul dePercin
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7797
Fax: 513-569-7105
E-Mail: dePercin.Paul@epamail.epa.gov

TECHNOLOGY DEVELOPER CONTACTS:

Joseph Hutton
Smith Environmental Technologies
Corporation
304 Inverness Way South, Suite 200
Englewood, CO 80112
303-790-1747
Fax: 303-799-0186

SOLIDITECH, INC.
(Solidification and Stabilization)

TECHNOLOGY DESCRIPTION:

This solidification and stabilization process immobilizes contaminants in soils and sludges by binding them in a concrete-like, leach-resistant matrix. Contaminated waste materials are collected, screened to remove oversized material, and introduced to the batch mixer (see figure below). The waste material is then mixed with water; Urrichem, a proprietary chemical reagent; proprietary additives; and pozzolanic material (fly ash), kiln dust, or cement. After it is thoroughly mixed, the treated waste is discharged from the mixer. Treated waste is a solidified mass with significant unconfined compressive strength (UCS), high stability, and a rigid texture similar to that of concrete.

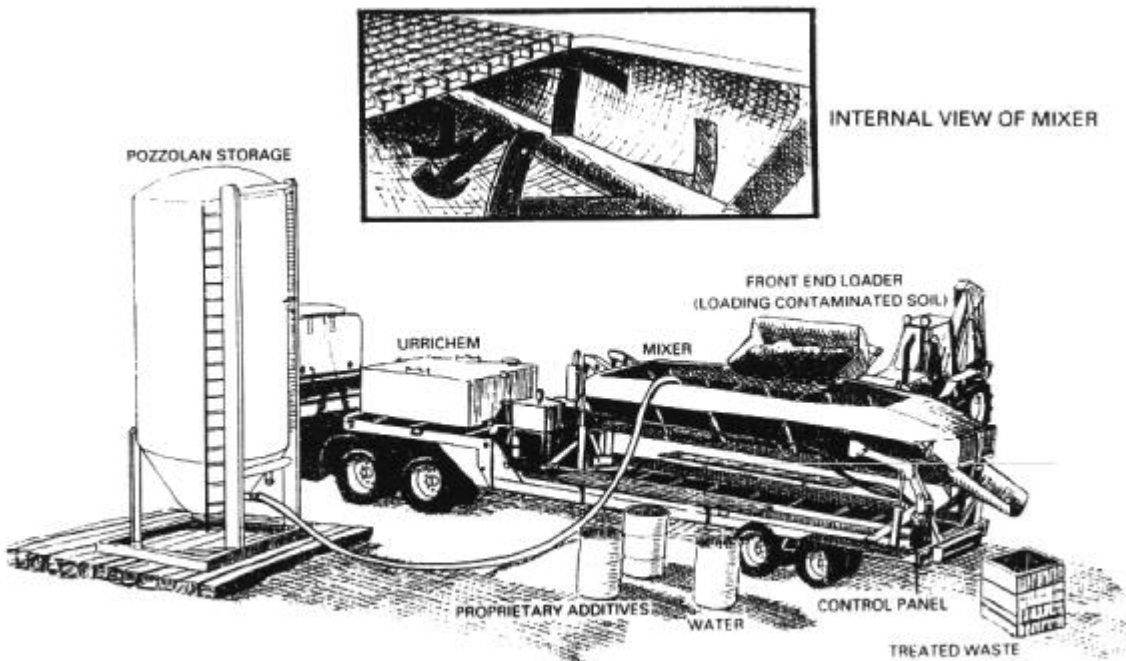
WASTE APPLICABILITY:

This process treats soils and sludges contaminated with organic compounds, metals, inorganic compounds, and oil and grease. Batch mixers of

various capacities can treat different volumes of waste.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1988. The solidification and stabilization process was demonstrated in December 1988 at the Imperial Oil Company/Champion Chemical Company Superfund site in Morganville, New Jersey. This site formerly contained both chemical processing and oil reclamation facilities. Soils, filter cakes, and oily wastes from an old storage tank were treated during the demonstration. These wastes were contaminated with petroleum hydrocarbons, polychlorinated biphenyls (PCB), other organic chemicals, and heavy metals. The Technology Evaluation Report (EPA/540/5-89/005a), Applications Analysis Report (EPA/540/A5-89/005), and Demonstration Bulletin (EPA/540/M5-89/005) are available from EPA.



Soliditech Processing Equipment

This technology is no longer available through a vendor. Contact the EPA Project Manager for further information.

DEMONSTRATION RESULTS:

Key findings from the Soliditech demonstration are summarized below:

- Extract and leachate analyses showed that heavy metals in the untreated waste were immobilized.
- The process solidified both solid and liquid wastes with high organic content (up to 17 percent), as well as oil and grease.
- Volatile organic compounds in the original waste were not detected in the treated waste.
- Physical test results of the solidified waste showed (1) UCS ranging from 390 to 860 pounds per square inch (psi); (2) very little weight loss after 12 cycles of wet and dry and freeze and thaw durability tests; (3) low permeability of the treated waste; and (4) increased density after treatment.
- The solidified waste increased in volume by an average of 22 percent. Because of solidification, the bulk density of the waste material increased by about 35 percent.
- Semivolatile organic compounds (phenols) were detected in the treated waste and the toxicity characteristic leaching procedure (TCLP) extracts from the treated waste, but not in the untreated waste or its TCLP extracts. The presence of these compounds is believed to result from chemical reactions in the waste treatment mixture.

- The oil and grease content of the untreated waste ranged from 2.8 to 17.3 percent (28,000 to 173,000 parts per million [ppm]). The oil and grease content of the TCLP extracts from the solidified waste ranged from 2.4 to 12 ppm.
- The pH of the solidified waste ranged from 11.7 to 12.0. The pH of the untreated waste ranged from 3.4 to 7.9.
- PCBs were not detected in any extracts or leachates from the treated waste.
- Visual observation of solidified waste revealed bulk oily material about 1 millimeter in diameter.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Jack Hubbard
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7507
Fax: 513-569-7620

SONOTECH, INC.
(Frequency-Tunable Pulse Combustion System)

TECHNOLOGY DESCRIPTION:

The Sonotech, Inc., frequency-tunable pulse combustion system (Sonotech system) is designed to significantly improve batch- and continuous-mode combustion or thermal processes such as incineration by creating large-amplitude, resonant pulsations inside the combustion chamber. This technology can be applied to new or existing combustion systems. The technology is used in fossil fuel combustion devices, residential natural gas furnaces, and industrial combustion systems. It should prove similarly beneficial to hazardous waste incineration and soil remediation applications.

The Sonotech system (see photograph below) consists of an air inlet, a combustor section, a tailpipe, a control panel, and safety features. This system is designed to improve an incinerator's

performance by (1) increasing mixing rates between the fuel and air, (2) increasing mixing rates between reactive gas pockets and ignition sources, and (3) increasing rates of heat and mass transfer between the gas and the burning waste. These improvements should (1) reduce the amount of excess air required to completely burn the waste, (2) increase destruction and removal efficiencies (DRE) of principal organic hazardous constituents, (3) minimize the formation of products of incomplete combustion, and (4) eliminate or minimize detrimental emissions or "puffs."

The Sonotech system has achieved sound amplitudes as high as 170 decibels and frequencies of 100 to 500 hertz within the combustion chamber. The high frequencies and velocities of these gas oscillations help mix the gases in the chamber and thus reduce or eliminate stratification effects.



Frequency-Tunable Pulse Combustion System Installed
at EPA's Incineration Research Facility

The Sonotech system can function alone or as a supplemental retrofit to an existing combustion system. In the latter application, the frequency-tunable pulse combustion system can supply as little as 2 to 10 percent of the total energy requirements. The total fuel supplied to the main burner and the Sonotech system should be less than the amount of fuel supplied to the main burner before retrofitting.

WASTE APPLICABILITY:

This technology can be used with any material that can be treated in a conventional incinerator. Sonotech, Inc., believes that the technology is ready for incineration of hazardous, municipal, and medical waste.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1992. The 6-week demonstration evaluated whether the technology improved the performance of a larger scale incineration system. To meet this goal, the pilot-scale rotary kiln incinerator at EPA's Incineration Research Facility (IRF) in Jefferson, Arkansas was retrofit with a Sonotech system. The demonstration took place from September to October 1994. The retrofit incinerator was used to treat coal- and oil-gasification wastes, traditionally incinerated with conventional technology. The Technology Capsule (EPA/540/R-95/502a) is available from EPA. More detailed results will be available from EPA in early 1997.

DEMONSTRATION RESULTS:

The Sonotech system increased the incinerator waste feed rate capacity by 13 to 21 percent compared to conventional combustion. As the demonstration waste had significant heat content,

the capacity increase was equivalent to a reduction in the auxiliary fuel needed to treat a unit mass of waste from 21,100 British thermal unit/pound (Btu/lb) for conventional combustion to 18,000 Btu/lb for the Sonotech system. Visual observations indicated improved mixing in the incinerator cavity with the Sonotech system operating.

Benzene and naphthalene DREs were greater than 99.99 percent. The average concentration of carbon monoxide exiting the afterburner, corrected to 7 percent oxygen, decreased from 20 parts per million (ppm) with conventional combustion to 14 ppm with the Sonotech system. The average afterburner exit nitrogen oxides concentration, corrected to 7 percent oxygen, decreased from 82 ppm with conventional combustion to 77 ppm with the Sonotech system. Average soot emissions exiting the afterburner, corrected to 7 percent oxygen, were reduced from 1.9 milligrams per dry standard cubic meter (mg/dscm) for conventional combustion to less than 1.0 mg/dscm with the Sonotech system. Total system combustion air requirements, determined from stoichiometric calculations, were lower with the Sonotech system in operation.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Marta K. Richards
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7692
Fax: 513-569-7676

TECHNOLOGY DEVELOPER CONTACT:

Ben Zinn
Sonotech, Inc.
3656 Paces Valley Road
Atlanta, GA 30327
404-894-3033
Fax: 404-894-2760

**STC REMEDIATION, A DIVISION OF
OMEGA ENVIRONMENTAL, INC.**
(formerly SILICATE TECHNOLOGY CORPORATION)
(Organic Stabilization and Chemical Fixation/Solidification)

TECHNOLOGY DESCRIPTION:

STC Remediation, a division of Omega Environmental, Inc. (STC Remediation), has developed both chemical organic stabilization and chemical fixation/solidification technologies that treat inorganic and organic solid hazardous wastes (see photograph below). Leachable organic contaminant concentrations are reduced to well below regulatory limits. The chemical fixation/solidification technology forms insoluble chemical compounds, reducing leachable inorganic contaminant concentrations in soils and sludges.

STC Remediation's technology has been successfully implemented on numerous full-scale hazardous waste remediation projects involving up to 100,000 cubic yards of waste per project.

These sites include Superfund sites and industrial sites across the United States and in Italy.

STC Remediation has evaluated various materials handling and mixing systems for use on full-scale remediation projects. Materials handling processes consist of pretreatment processes for screening and crushing contaminated soils, and placement and conveying systems for handling treated material. Mixing systems consist of various batching plants, pug mills, and high-shear batch mixing systems to properly meter and mix reagents with contaminated soils. STC Remediation provides full on-site technical support to ensure effective application of the treatment technologies, documentation, and quality assurance/quality control procedures during the treatment process.



Treatment of Contaminated Soil

WASTE APPLICABILITY:

STC Remediation's technology can treat a wide variety of hazardous soils, sludges, and wastewaters, including the following:

- Soils and sludges contaminated with inorganics, including most metals, cyanides, fluorides, arsenates, chromates, and selenium
- Soils and sludges contaminated with organics, including halogenated aromatics, polynuclear aromatic hydrocarbons, and aliphatic compounds
- Wastewaters contaminated with heavy metals and emulsified and dissolved organic compounds, excluding low-molecular-weight organic contaminants such as alcohols, ketones, and glycols

STATUS:

This technology was accepted into the SITE Demonstration Program in 1988. STC Remediation's demonstration project was completed in November 1990 at the Selma Pressure Treating (SPT) Superfund site in Selma, California. STC Remediation was subsequently selected for the full-scale remediation of the SPT site, which is contaminated with organics, mainly pentachlorophenol (PCP), and inorganics, mainly arsenic, chromium, and copper. The SPT site was remediated in 1993 using STC Remediation's treatment process. The Applications Analysis Report (EPA/540/AR-92/010) is available through the National Technology Information Service (Order No. PB93-172948). The Technology Evaluation Report (EPA/540/R-92/010) and Demonstration Bulletin (EPA/540/MR-92/010) are available from EPA.

DEMONSTRATION RESULTS:

The SITE demonstration yielded the following results:

- The organic stabilization technology reduced total extractable PCP concentrations up to 97 percent. The chemical fixation/stabilization technology

stabilized the residual PCP concentrations to very low leachable levels (from 5 to less than 0.3 milligrams per liter).

- STC Remediation's technology immobilized arsenic and copper, while chromium remained well within regulatory limits.
- Long-term monitoring at 18 and 32 months following the demonstration project provided comparable results for PCP, arsenic, and copper, while chromium remained well within regulatory limits.
- The treated wastes had moderately high unconfined compressive strength, averaging 300 pounds per square inch (psi) after 28 days, increasing to more than 700 psi after 18 months.
- Permeability of the treated waste was low (less than 1.7×10^{-7} centimeters per second). The relative cumulative weight loss after 12 wet/dry and 12 freeze/thaw cycles was negligible (less than 1 percent).
- Treatment costs depend on specific waste characteristics.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Edward Bates

U.S. EPA

National Risk Management Research
Laboratory

26 West Martin Luther King Drive

Cincinnati, OH 45268

513-569-7774

Fax: 513-569-7676

TECHNOLOGY DEVELOPER CONTACTS:

Scott Larsen or Stephen Pegler

STC Remediation

7650 East Redfield Road, Suite D-5

Scottsdale, AZ 85260

602-948-7100

Fax: 602-991-3173

TERRA-KLEEN RESPONSE GROUP, INC. (Solvent Extraction Treatment System)

TECHNOLOGY DESCRIPTION:

Terra-Kleen Response Group, Inc. (Terra-Kleen), developed the solvent extraction treatment system to remove semivolatile and nonvolatile organic contaminants from soil. This batch process system uses a proprietary solvent blend to separate hazardous constituents from soils, sediments, sludge, and debris.

A flow diagram of the Terra-Kleen treatment system is shown below. Treatment begins after excavated soil is loaded into the solvent extraction tanks. Clean solvent from the solvent storage tank is pumped into the extraction tanks. The soil and solvent mixture is held in the extraction tanks long enough to solubilize organic contaminants into the solvent, separating them from the soil. The contaminant-laden solvent is then removed from the extraction tanks and pumped into the sedimentation tank. Suspended solids settle or are flocculated in the sedimentation tank, and are then removed.

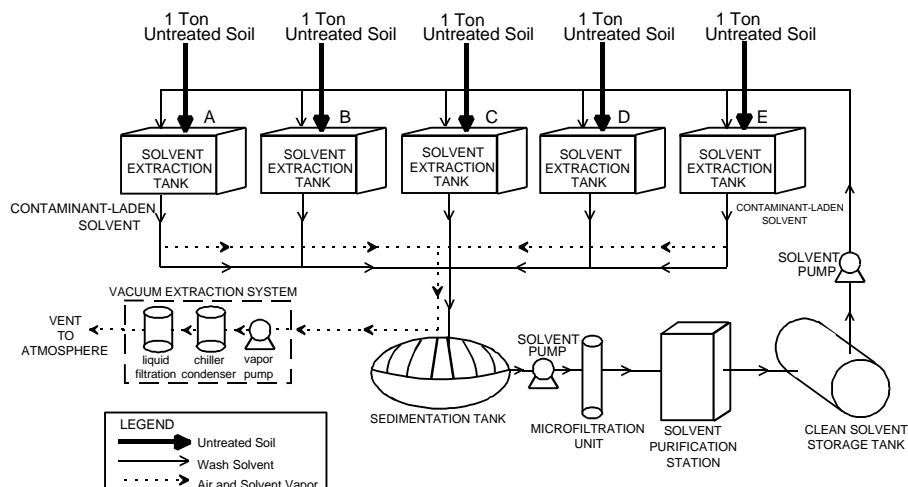
Following solvent extraction of the organic contaminants, any residual solvent in the soil is removed using soil vapor extraction and biological treatment. Soil vapor extraction removes the majority of the residual solvent, while biological treatment reduces residual solvent to trace levels. The treated soils are then removed from the

extraction tanks.

Contaminant-laden solvents are cleaned for reuse by Terra-Kleen's solvent regeneration process. The solvent regeneration process begins by pumping contaminant-laden solvent from the sedimentation tank through a microfiltration unit and a proprietary solvent purification station. The microfiltration unit first removes any fines remaining in the solvent. The solvent purification station separates organic contaminants from the solvent and concentrates them, reducing the amount of hazardous waste for off-site disposal. The solvent is pumped into the solvent storage tank for use in treating additional soil.

WASTE APPLICABILITY:

The Terra-Kleen solvent extraction treatment system is a waste minimization process designed to remove the following organic contaminants from soils: polychlorinated biphenyls (PCB), chlorinated pesticides, polynuclear aromatic hydrocarbons (PAH), pentachlorophenol, creosote, polychlorinated dibenzo-p-dioxins (PCDD), and polychlorinated dibenzofurans (PCDF). The technology also has the capacity to remove organic contaminants, such as PCBs, from low-level radioactive wastes. The system is transportable and can be configured to treat small quantities of soil (1



to 1,000 cubic yards) as well as large volumes generated at remedial sites.

STATUS:

The solvent extraction treatment system was demonstrated during May and June 1994 at Naval Air Station North Island (NASNI) Site 4 in San Diego, California. Soils at Site 4 are contaminated with heavy metals, volatile organic compounds (VOC), PCBs (Aroclor 1260), and furans. The Technology Capsule (EPA/540/R-94/521a) and Demonstration Bulletin (EPA/540/MR-94/521) are available from EPA. The Innovative Technology Evaluation Report will be available in 1997.

Several full-scale solvent extraction units are in operation at this time. Terra-Kleen has removed PCBs from 10,000 tons of soil at three sites within NASNI, and completed cleanup of a remote Air Force Base PCB site in Alaska. A full-scale system has also removed DDT, DDD, and DDE from clay soil at the Naval Communication Station in Stockton, California.

Terra-Kleen has been selected to participate in the Rapid Commercialization Initiative (RCI). RCI was created by the Department of Commerce, Department of Defense, Department of Energy (DOE), and EPA to assist in the integration of innovative technologies into the marketplace. Under RCI, Terra-Kleen is expanding its capabilities to process PCBs and VOCs in low-level radioactive wastes. The pilot project for this effort will begin in early 1997 at DOE's Fernald Plant near Cincinnati, Ohio.

DEMONSTRATION RESULTS:

Findings from the SITE demonstration are summarized as follows:

- PCB Aroclor 1260 concentrations were reduced from an average of 144 milligrams per kilogram (mg/kg) to less than 1.71 mg/kg, an overall removal efficiency of 98.8 percent.

- NASNI untreated soil contained a moisture content of 0.83 percent; a particle size distribution of 80 percent sand, 15 percent gravel, and 5 percent clay; and an overall oil and grease concentration of 780 mg/kg.
- Hexachlorodibenzofuran and pentachlorodibenzofuran concentrations were reduced by 92.7 percent and 84.0 percent, respectively. Oil and grease concentrations were reduced by 65.9 percent.

Additional data were collected at the Naval Communication Station in Stockton, California. The system treated soil contaminated with chlorinated pesticides at concentrations up to 600 mg/kg. Samples taken during system operation indicated that soil contaminated with DDD, DDE, and DDT was reduced below 1 mg/kg, an overall removal efficiency of 98.8 to 99.8 percent.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Mark Meckes or Terrence Lyons

U.S. EPA

National Risk Management Research
Laboratory

26 West Martin Luther King Drive
Cincinnati, OH 45268

513-569-7348 or 513-569-7589

Fax: 513-569-7328 or 513-569-7676

TECHNOLOGY DEVELOPER CONTACT:

Alan Cash

Terra-Kleen Response Group, Inc.

P.O. Box 2504

Del Mar, CA 92014

619-558-8762

Fax: 619-558-8759

TERRA VAC (In Situ and Ex Situ Vacuum Extraction)

TECHNOLOGY DESCRIPTION:

In situ or ex situ vacuum extraction is a process that removes volatile organic compounds (VOC) and many semivolatile organic compounds (SVOC) from the vadose, or unsaturated, soil zone. These compounds can often be removed from the vadose zone before they contaminate groundwater. Soil piles also may be cleaned by ex situ extraction vacuum. The in situ vacuum extraction process has been patented by others and licensed to Terra Vac and others in the United States.

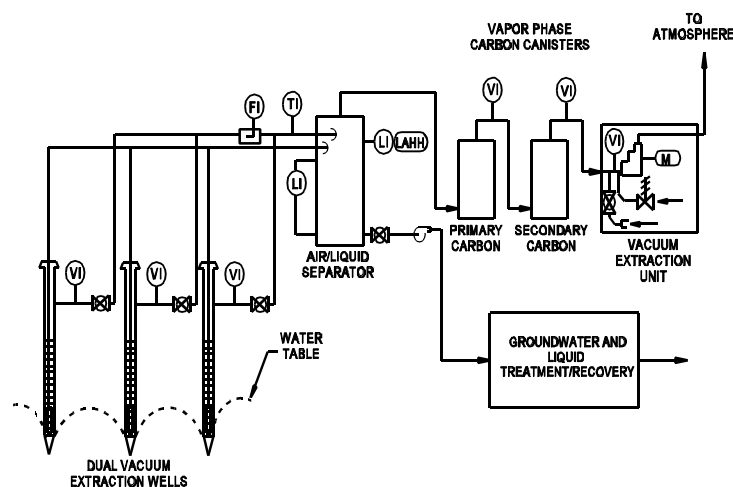
The extraction process uses readily available equipment, including extraction and monitoring wells, manifold piping, air-liquid separators, and vacuum pumps. Vacuum extraction systems may vent directly to the atmosphere or through an emission control device. After the contaminated area is generally characterized, extraction wells are installed and connected by piping to the vacuum extraction and vapor treatment systems.

First, a vacuum pump creates a vacuum in the soil causing in situ volatilization and draws air through the subsurface. Contaminants are removed from the

extraction wells and pass to the air-liquid separator. The vapor-phase contaminants may be treated with an activated carbon adsorption filter, a catalytic oxidizer, or another emission control system before the gases are discharged to the atmosphere. Subsurface vacuum and soil vapor concentrations are monitored with vadose zone monitoring wells.

The technology can be used in most hydrogeological settings and may reduce soil contaminant levels from saturated conditions to nondetectable. The process also works in fractured bedrock and less permeable soils (clays) with sufficient permeability. The process may be used to enhance bioremediation (bioventing). It also may be used in conjunction with dual vacuum extraction, soil heating, pneumatic fracturing, and chemical oxidation to recover a wide range of contaminants. The figure below illustrates one possible configuration of the process.

Typical contaminant recovery rates range from 20 to 2,500 pounds (10 to 1,000 kilograms) per day, depending on the degree of site contamination and the design of the vacuum extraction system.



In Situ Dual Vacuum Extraction Process

WASTE APPLICABILITY:

The vacuum extraction technology may treat soils containing virtually any VOC. It has removed over 40 types of chemicals from soils and groundwater, including solvents and gasoline- and diesel-range hydrocarbons.

STATUS:

The process was accepted into the SITE Demonstration Program in 1987. The process was demonstrated under the SITE Demonstration Program at the Groveland Wells Superfund site in Groveland, Massachusetts, from December 1987 through April 1988. The technology remediated soils contaminated with trichloroethene (TCE). The Technology Evaluation Report (EPA/540/5-89/003a) and Applications Analysis Report (EPA/540/A5-89/003) are available from EPA.

The vacuum extraction process was first demonstrated at a Superfund site in Puerto Rico in 1984. Terra Vac has since applied the technology at more than 20 additional Superfund sites and at more than 700 other waste sites throughout the United States, Europe, and Japan.

DEMONSTRATION RESULTS:

During the Groveland Wells SITE demonstration, four extraction wells pumped contaminants to the process system. During a 56-day period, 1,300 pounds of VOCs, mainly TCE, were extracted from both highly permeable strata and less permeable (10^{-7} centimeters per second) clays. The vacuum extraction process achieved nondetectable VOC levels at some locations and reduced the VOC concentration in soil gas by 95 percent. Average reductions of soil concentrations during the demonstration program were 92 percent for sandy soils and 90 percent for clays. Field evaluations yielded the following conclusions:

- VOCs can be reduced to nondetectable levels; however, some residual VOC concentrations many remain in the treated soils.

- Permeability of soils is a major consideration when applying this technology. Ideal measured hydraulic conductivities are 10^{-4} to 10^{-8} centimeters per second.
- Pilot demonstrations are necessary at sites with complex geology or contaminant distributions.
- Treatment costs are typically \$40 per ton of soil but can range from less than \$10 to \$80 per ton of soil, depending on the size of the site and the requirements for gas effluent or wastewater treatment.
- Contaminants should have a Henry's constant of 0.001 or higher.

FOR FURTHER INFORMATION:

TECHNOLOGY DEVELOPER CONTACTS:

Loren Martin
Terra Vac
Windsor Industrial Park, Building 15
92 N. Main Street
P.O. Box 468
Windsor, NJ 08561-0468
609-371-0070
Fax: 609-371-9446

James Malot
Terra Vac
356 Fortaleza Street
P.O. Box 1591
San Juan, PR 00902-1591
787-723-9171
Fax: 787-725-8750
E-Mail: jim@pr.terravac.com
Home page: www.terravac.com

TEXACO INC.
(Texaco Gasification Process)

TECHNOLOGY DESCRIPTION:

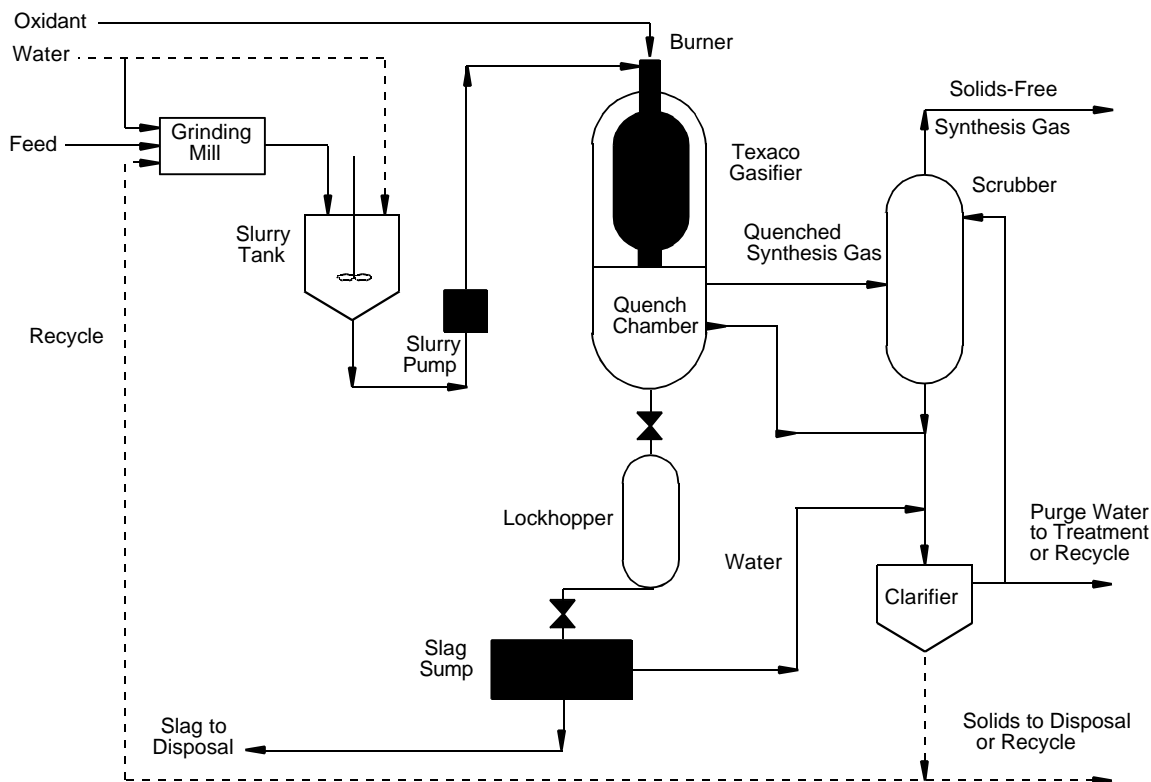
The Texaco Gasification Process (TGP) is an entrained-bed, noncatalytic, partial oxidation process in which carbonaceous substances react at elevated temperatures and pressures, producing a gas containing mainly carbon monoxide and hydrogen (see figure below). This product, called synthesis gas, can be used to produce other chemicals or can be burned as fuel. Inorganic materials in the feed melt are removed as a glass-like slag.

This technology has operated commercially for over 40 years with feedstocks such as natural gas, heavy oil, coal, and petroleum coke. The TGP processes waste feedstocks at pressures above 20 atmospheres and temperatures between 2,200 and 2,800 °F. Slurried wastes are pumped to a specially designed

injector mounted at the top of the refractory-lined gasifier. The waste feed, oxygen, and an auxiliary fuel such as coal react and flow downward through the gasifier to a quench chamber that collects the slag. The slag is eventually removed through a lockhopper. A scrubber further cools and cleans the synthesis gas. Fine particulate matter removed by the scrubber may be recycled to the gasifier; a sulfur recovery system may also be added.

After the TGP converts organic materials into synthesis gas, the cooled, water-scrubbed product gas, consisting mainly of hydrogen and carbon monoxide, essentially contains no hydrocarbons heavier than methane. Metals and other ash constituents become part of the glassy slag.

Texaco is designing a transportable system to process about 100 tons of hazardous waste per day.



Texaco Gasification Process

This system would produce about 6 million standard cubic feet of usable synthesis gas per day with a heating value of approximately 250 British thermal units per standard cubic foot.

WASTE APPLICABILITY:

The TGP can treat the following wastes:

- Contaminated soils, sludges, and sediments that contain both organic and inorganic constituents
- Chemical wastes
- Petroleum residues

Solids in the feed are ground and pumped in a slurry containing 40 to 70 percent solids by weight and 30 to 60 percent liquid, usually water.

Texaco has demonstrated gasification of coal liquefaction residues, petroleum production tank bottoms, municipal sewage sludge, and surrogate contaminated soil. Texaco is operating a gasification facility at its El Dorado, Kansas refinery that will convert up to 170 tons per day of petroleum coke and Resource Conservation and Recovery Act-listed refinery wastes into usable synthesis gas.

STATUS:

The TGP was accepted into the SITE Demonstration Program in July 1991. A demonstration was conducted in January 1994 at Texaco's Montebello Research Laboratory in California using a mixture of clean soil, coal, and soil from the Purity Oil Sales Superfund site, located in Fresno, California. The mixture was slurried and spiked with lead, barium, and chlorobenzene. Forty tons of slurry was gasified during three demonstration runs. The Demonstration Bulletin (EPA/540/MR-95/514), Technology Capsule (EPA/540/R-94/514a), and Innovative Technology Evaluation Report (EPA/540/R-94/514) are available from EPA.

DEMONSTRATION RESULTS:

Findings from the SITE demonstration are summarized below:

- The average composition of the dry synthesis gas product from the TGP consisted of 37 percent hydrogen, 36 percent carbon monoxide, and 21 percent carbon dioxide. The only remaining organic contaminant greater than 0.1 part per million (ppm) was methane at 55 ppm.
- The destruction and removal efficiency for the volatile organic spike (chlorobenzene) was greater than the 99.99 percent goal.
- Samples of the primary TGP solid product, coarse slag, averaged below the toxicity characteristic leaching procedure (TCLP) limits for lead (5 milligrams per liter [mg/L]) and barium (100 mg/L). Volatile heavy metals tended to partition to and concentrate in the secondary TGP solid products, fine slag and clarifier solids. These secondary products were above the TCLP limit for lead.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Marta K. Richards

U.S. EPA

National Risk Management Research

Laboratory

26 West Martin Luther King Drive

Cincinnati, OH 45268

513-569-7692

Fax: 513-569-7676

TECHNOLOGY DEVELOPER CONTACT:

John Winter

Alternate Energy Department

Texaco Inc.

329 N. Durfee Avenue

S. El Monte, CA 91733

310-908-7387

Fax: 310-699-7408

TORONTO HARBOUR COMMISSION (Soil Recycling)

TECHNOLOGY DESCRIPTION:

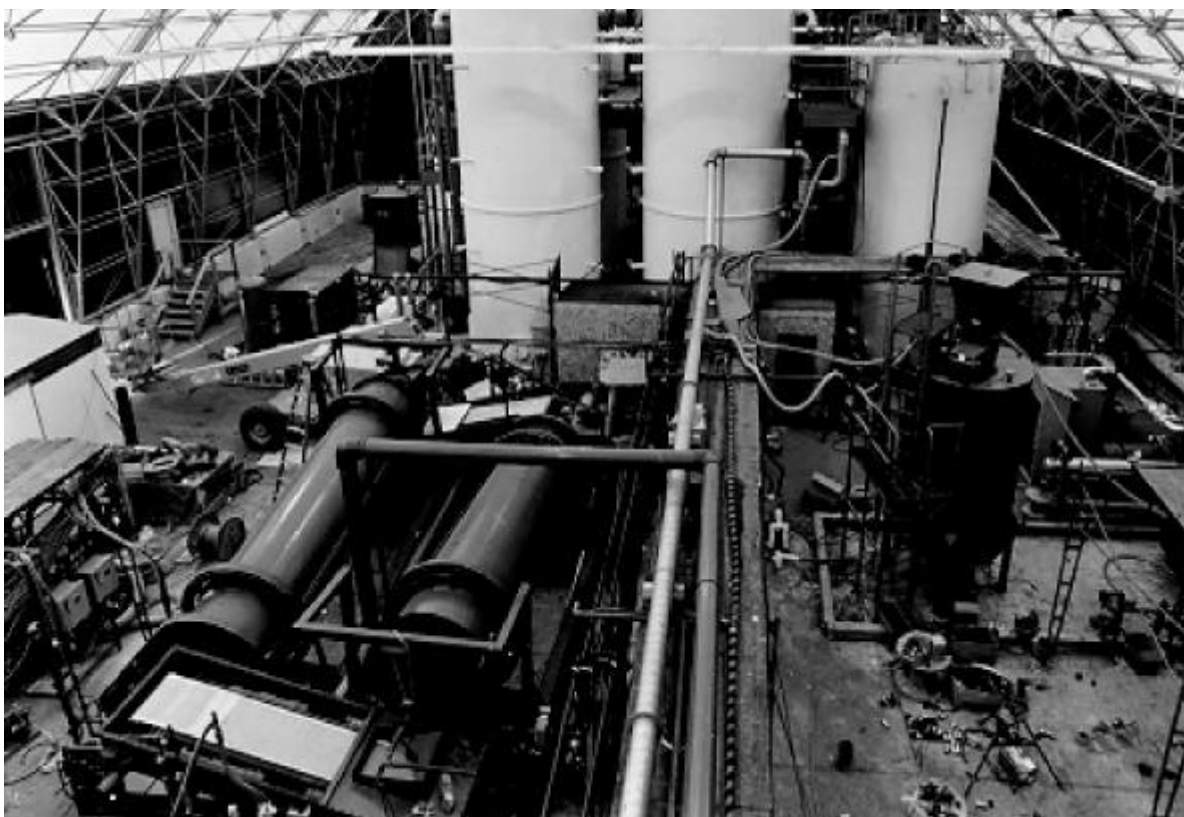
The Toronto Harbour Commission's (THC) soil recycling process removes inorganic and organic contaminants from soil to produce a reusable fill material (see photograph below). The process consists of three technologies operating in series: a soil washing technology; a technology that removes inorganic contamination by chelation; and a technology that uses chemical and biological treatment to reduce organic contaminants.

The process uses an attrition soil wash plant to remove relatively uncontaminated coarse soil fractions using mineral processing equipment while concentrating the contaminants in a fine slurry which is routed to the appropriate process for further treatment. The wash process includes a trommel washer to remove clean gravel, hydrocyclones to

separate the contaminated fines, an attrition scrubber to free fines from sand particles, and a density separator to remove coal and peat from the sand fraction.

If only inorganic contaminants are present, the slurry can be treated in the inorganic chelator unit. This process uses an acid leach to free the inorganic contaminant from the fine slurry and then removes the metal using solid chelating agent pellets in a patented countercurrent contactor. The metals are recovered by electrowinning from the chelation agent regenerating liquid.

Organic removal is accomplished by first chemically pretreating the slurry from the wash plant or the metal removal process. Next, biological treatment is applied in upflow slurry reactors using the bacteria which have developed naturally in the soils.



Soil Washing Plant (Metal Extraction Screw tubes in Foreground
and Bioslurry Reactors in Background)

The treated soil is dewatered using hydrocyclones and returned to the site from which it was excavated.

WASTE APPLICABILITY:

The technology is designed to reduce organic and inorganic contaminants in soils. The process train approach is most useful when sites have been contaminated as a result of multiple uses over a period of time. Typical sites where the process train might be used include refinery and petroleum storage facilities, sites with metal processing and metal recycling histories, and manufactured gas and coal or coke processing and storage sites. The process is less suited to soils with undesirable high inorganic constituents which result from the inherent mineralogy of the soils.

STATUS:

The THC soil recycling process was accepted into the SITE Demonstration Program in 1991. The soil recycling process was demonstrated at a site within the Toronto Port Industrial District that had been used for metals finishing and refinery products and petroleum storage. Demonstration sampling took place in April and May 1992.

Results have been published in the Demonstration Bulletin (EPA/520-MR-92/015), the Applications Analysis Report (EPA/540-AR-93/517), the Technology Evaluation Report (EPA/540/R-93/517), and the Technology Demonstration Summary (EPA/540/SR-93/517). These reports are available from EPA.

This technology is no longer available through a vendor. For further information on the technology, contact the EPA Project Manager.

DEMONSTRATION RESULTS:

The demonstration results showed that soil washing produced clean coarse soil fractions and concentrated the contaminants in the fine slurry.

The chemical treatment process and biological slurry reactors, when operated on a batch basis with a nominal 35-day retention time, achieved at least a 90 percent reduction in simple polyaromatic hydrocarbon compounds such as naphthalene, but did not meet the approximately 75 percent reduction in benzo(a)pyrene required to achieve the cleanup criteria.

The biological process discharge did not meet the cleanup criteria for oil and grease, and the process exhibited virtually no removal of this parameter. THC believes that the high outlet oil and grease values are the result of the analytical extraction of the biomass developed during the process.

The hydrocyclone dewatering device did not achieve significant dewatering. Final process slurries were returned to the excavation site in liquid form.

The metals removal process achieved a removal efficiency for toxic heavy metals such as copper, lead, mercury, and nickel of approximately 70 percent.

The metals removal process equipment and chelating agent were fouled by free oil and grease contamination, forcing sampling to end prematurely. Biological treatment or physical separation of oil and grease will be required to avoid such fouling.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Teri Richardson

U.S. EPA

National Risk Management Research

Laboratory

26 West Martin Luther King Drive

Cincinnati, OH 45268

513-569-7949

Fax: 513-569-7105

U.S. FILTER/ZIMPRO, INC.
(formerly **ULTROX**, A DIVISION OF ZIMPRO ENVIRONMENTAL, INC.)
(Ultraviolet Radiation and Oxidation)

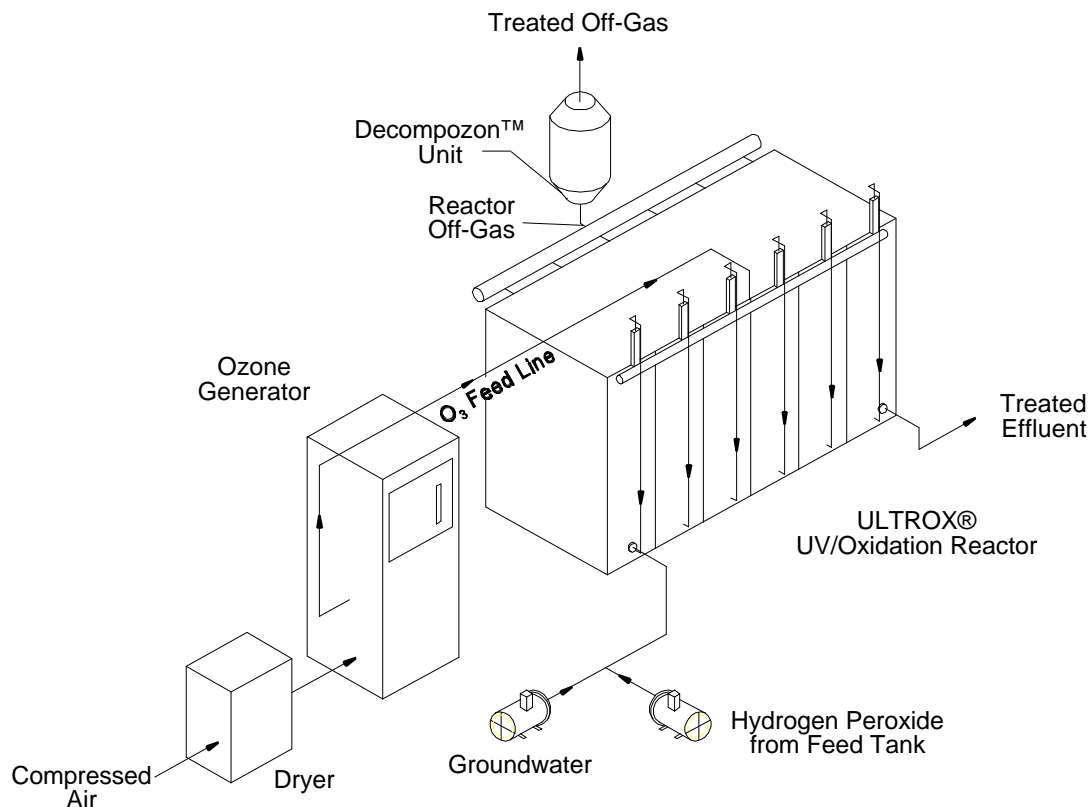
TECHNOLOGY DESCRIPTION:

This ultraviolet (UV) radiation and oxidation technology uses UV radiation, ozone, and hydrogen peroxide to destroy toxic organic compounds, particularly chlorinated hydrocarbons, in water. The technology oxidizes compounds that are toxic or refractory (resistant to biological oxidation) to parts per million (ppm) or parts per billion (ppb) levels.

The UV radiation and oxidation system consists of the UV-oxidation reactor, an air compressor and ozone generator module, and a hydrogen peroxide feed system (see figure below). The system is skid-mounted and portable, and permits on-site treatment

of a wide variety of liquid wastes. Reactor size is determined by the expected wastewater flow rate and the necessary hydraulic retention time needed to treat the contaminated water. The approximate UV intensity, and ozone and hydrogen peroxide doses, are determined from pilot-scale studies.

Reactor influent is simultaneously exposed to UV radiation, ozone, and hydrogen peroxide to oxidize the organic compounds. Off-gas from the reactor passes through a catalytic ozone destruction Decompozon™ unit, which reduces ozone levels before air venting. The Decompozon™ unit also destroys volatile organic compounds (VOC) stripped off in the reactor. Effluent from the reactor



UV Radiation and Oxidation System (Isometric View)

is tested and analyzed before disposal.

WASTE APPLICABILITY:

The UV radiation and oxidation system treats contaminated groundwater, industrial wastewaters, and leachates containing halogenated solvents, phenol, pentachlorophenol, pesticides, polychlorinated biphenyls, explosives, benzene, toluene, ethylbenzene, xylene, methyl tertiary butyl ether, and other organic compounds. The system also treats low-level total organic carbon and reduces chemical oxygen demand and biological oxygen demand.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1989. A field-scale demonstration of the system was completed in March 1989 at the Lorentz Barrel and Drum Company site in San Jose, California. The testing program was designed to evaluate system performance while varying five operating parameters: (1) influent pH, (2) retention time, (3) ozone dose, (4) hydrogen peroxide dose, and (5) UV radiation intensity. The Demonstration Bulletin (EPA/540/M5-89/012), Technology Demonstration Summary (EPA/540/S5-89/012), Applications Analysis Report (EPA/540/A5-89/012), and Technology Evaluation Report (EPA/540/5-89/012) are available from EPA.

The technology is fully commercial, with over 30 systems installed. Units with flow rates ranging from 5 gallons per minute (gpm) to 1,050 gpm are in use at various industries and site remediations, including aerospace, U.S. Department of Energy, U.S. Department of Defense, petroleum, pharmaceutical, automotive, woodtreating, and municipal facilities.

UV radiation and oxidation technology has been included in records of decision for several Superfund sites where groundwater pump-and-treat remediation methods will be used.

DEMONSTRATION RESULTS:

Contaminated groundwater treated by the system during the SITE demonstration met regulatory standards at the appropriate parameter levels. Out of 44 VOCs in the wastewater, trichloroethene, 1,1-dichloroethane, and 1,1,1-trichloroethane were chosen as indicator parameters. All three are relatively refractory to conventional oxidation.

The Decompozon™ unit reduced ozone to less than 0.1 ppm, with efficiencies greater than 99.99 percent. VOCs present in the air within the treatment system were not detected after passing through the Decompozon™ unit. The system produced no harmful air emissions. Total organic carbon removal was low, implying partial oxidation of organics without complete conversion to carbon dioxide and water.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Norma Lewis
U.S. EPA
National Risk Management Research
Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7665
Fax: 513-569-7787

TECHNOLOGY DEVELOPER CONTACT:

William Himebaugh
U.S. Filter/Zimpro, Inc.
7755 Center Avenue, Suite 1120
Huntington Beach, CA 92647
714-545-5557
Fax: 714-557-5396

**UNITED STATES ENVIRONMENTAL
PROTECTION AGENCY**
(Excavation Techniques and Foam Suppression Methods)

TECHNOLOGY DESCRIPTION:

Excavation techniques and foam suppression methods have been developed through a joint EPA effort involving the National Risk Management Research Laboratory (Cincinnati, Ohio), Air and Energy Engineering Research Laboratory (Research Triangle Park, North Carolina), and EPA Region 9 to evaluate control technologies during excavation operations.

In general, excavating soil contaminated with volatile organic compounds (VOC) results in fugitive air emissions. When using this technology, the area to be excavated is surrounded by a temporary enclosure (see photograph below). Air from the enclosure is vented through an emission control system before being released to the atmosphere. For example, in the case of hydrocarbon and sulfur dioxide emissions, a

scrubber and a carbon adsorption unit would be used to treat emissions. As an additional emission control method, a vapor suppressant foam can be applied to the soil before and after excavation.

WASTE APPLICABILITY:

This technology is suitable for controlling VOC and sulfur dioxide emissions during excavation of contaminated soil.

STATUS:

This technology was demonstrated at the McColl Superfund site in Fullerton, California, in June and July 1990. An enclosure 60 feet wide, 160 feet long, and 26 feet high was erected over an area contaminated with VOCs and sulfur dioxide. A backhoe removed the overburden and excavated underlying waste. Three distinct types of waste



Excavation Area Enclosure

were encountered during excavation: oily mud, tar, and hard coal-like char.

The following documents, which contain results from the demonstration, are available from EPA:

- Applications Analysis Report
(EPA/540/AR-92/015)
- Technology Evaluation Report
(EPA/540/R-93/015)
- Demonstration Summary
(EPA/540/SR-92/015)

DEMONSTRATION RESULTS:

During excavation, the 5-minute average air concentrations within the enclosed area were up to 1,000 parts per million (ppm) for sulfur dioxide and up to 492 ppm for total hydrocarbons (THC). The air pollution control system removed up to 99 percent of the sulfur dioxide and up to 70 percent of the THCs.

The concentrations of air contaminants inside the enclosure were higher than expected. These high concentrations were due in part to the inability of the vapor suppressant foams to form an impermeable membrane over the exposed wastes. The foam reacted with the highly acidic waste, causing the foam to degrade. Furthermore, purge water from foaming activities made surfaces slippery for workers and equipment.

A total of 101 cubic yards of overburden and 137 cubic yards of contaminated waste was excavated. The tar waste was solidified and stabilized by mixing with fly ash, cement, and water in a pug mill. The char wastes did not require further processing.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:

Jack Hubbard

U.S. EPA

National Risk Management Research

Laboratory

26 West Martin Luther King Drive

Cincinnati, OH 45268

513-569-7507

Fax: 513-569-7620